

Metrication of U.S. Shipbuilding - The Challenges and the Opportunities

U. S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION, NAVAL SURFACE
WARFARE CENTER

in cooperation with

Newport News Shipbuilding

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE OCT 1993		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Metrication of U.S. Shipbuilding - The Challenges and the Opportunities				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Surface Warfare Center CD Code 2230-Design Integration Tools Bldg 192, Room 128 9500 MacArthur Blvd, Bethesda, MD 20817-5000				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 216	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

This report / manual was prepared as an account of U.S. government sponsored work. Neither the United States, nor the Carderock Division, Naval Surface Warfare Center (CDNSW) - formerly The David Taylor Research Center-DTRC, nor any person acting on behalf of the CDNSW (a) makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness or usefulness of the information contained in this report/ manual, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or (b) assumes any liabilities with respect to the use of or for damages resulting from the use of any information, apparatus, method, or process disclosed in the report / manual. As used in the above, "persons acting on behalf of the CDNSW" includes any employee, contractor, or subcontractor to the contractor of the CDNSW to the extent that such employee, contractor or subcontractor to the contractor prepares, handles, or distributes, or provides access to any information pursuant to his employment or contract or subcontract to the contractor with the CDNSW. ANY POSSIBLE IMPLIED WARRANTIES OF MERCHANTABILITY AND /OR FITNESS FOR PURPOSE ARE SPECIFICALLY DISCLAIMED.

THE NSRP NEEDS YOUR EVALUATION OF THIS REPORT!

PLEASE RETURN A RESPONSE CARD AFTER READING REPORT.

NSRP READER RESPONSE CARD

We would appreciate your comments on this report. Please take a few minutes to complete and return this postage-paid card. Thank you.

Name _____

Organization _____

Phone _____

• *Overall Quality of Report*

☐ Excellent ☐ Good ☐ Fair ☐ Poor

• *Useful to You/Your Organization*

☐ Very Useful ☐ Moderately Useful ☐ N/A

• *Did/Will your organization implement the results of this project?* ☐ Yes ☐ No

If not, why? _____

• *How Did You Receive Report?*

☐ Mailed directly to you

☐ Referred to you by someone else

• *Did/Will You Pass Report On To*

Someone Else? ☐ Yes ☐ No

• *In Your Opinion, Is Anything Missing That Would Make This Report Better?*

☐ Yes _____

• *General Comments*

NSRP 0399

NSRP READER RESPONSE CARD

We would appreciate your comments on this report. Please take a few minutes to complete and return this postage-paid card. Thank you.

Name _____

Organization _____

Phone _____

• *Overall Quality of Report*

☐ Excellent ☐ Good ☐ Fair ☐ Poor

• *Useful to You/Your Organization*

☐ Very Useful ☐ Moderately Useful ☐ N/A

• *Did/Will your organization implement the results of this project?* ☐ Yes ☐ No

If not, why? _____

• *How Did You Receive Report?*

☐ Mailed directly to you

☐ Referred to you by someone else

• *Did/Will You Pass Report On To*

Someone Else? ☐ Yes ☐ No

• *In Your Opinion, Is Anything Missing That Would Make This Report Better?*

☐ Yes _____

• *General Comments*

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS MAIL PERMIT NO. 1 NEWPORT NEWS, VA

NSRP PROGRAM MANAGER
W. G. BECKER
NEWPORT NEWS SHIPBUILDING
NEWPORT NEWS, VA 23607

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS MAIL PERMIT NO. 1 NEWPORT NEWS, VA

NSRP PROGRAM MANAGER
W. G. BECKER
NEWPORT NEWS SHIPBUILDING
NEWPORT NEWS, VA 23607

METRICATION OF U.S. SHIPBUILDING - THE CHALLENGES AND THE OPPORTUNITIES

A report on the issues facing the U.S. shipbuilding industry in
a metric marketplace

Prepared By

Peterson Builders Inc.

Under Contract to:

Newport News Shipbuilding

Under the Auspices of:

The National Shipbuilding Research Program

OCTOBER 1993

TABLE OF CONTENTS

ACKNOWLEDGEMENTS.....	i
INTRODUCTION.....	ii
METHODOLOGY.....	iv
EXECUTIVE SUMMARY.....	vi
1.0 THE METRIC BACKGROUND AND CURRENT STATE OF AFFAIRS1	
1.1 BACKGROUND.....	1
1.2 U.S. INITIATIVES.....	2
1.3 GOVERNMENT REACTION TO GLOBAL DEVELOPMENTS....	6
2.0 ACTION OF GOVERNMENT AGENCIES AFFECTING MARINE	
INDUSTRIES.....	11
2.1 THE NAVY COMPLIES WITH EXECUTIVE ORDER 12770	11
2.2 OTHER GOVERNMENT INITIATIVES AFFECTING MARINE ..	
INDUSTRIES	15
2.2.1 Coast Guard.....	15
2.2.2 Maritime Administration (MARAD).....	15
2.3 ASSESSMENT.....	18
3.0 METRICATION - U.S. SHIPBUILDING PROSPECTS.....	21
3.1 OVERVIEW.....	21
3.2 INDUSTRY ISSUES.....	21
3.3 MARKET DEMAND	22
3.3.1 Government/Military New Construction	23
3.3.2 Commercial - Oceangoing	25
3.3.3 Commercial - Inland/Coastal.....	26
3.3.4 Repair/Conversion	27
3.3.5 Market Overview.....	28
4.0 PRIORITY ISSUES.....	31
4.1 SUPPLY AVAILABILITY.....	31
4.1.1 Structural Steel Plate and Shapes	32
4.1.2 Fasteners	32
4.1.3 Propulsion, Steering Machinery	32
4.1.4 Mechanical Components.....	33
4.1.5 Pipe and Piping Components.....	33
4.1.6 Electrical Cable and Components.....	34
4.1.7 Deck Machinery.....	35
4.2 WORKFORCE TRAINING.....	35
4.2.1 Training Guidelines.....	36
4.2.2 Metric Theory and Conversion (MT&C).....	37
4.2.3 Metric Application Training.....	38
4.2.4 Metric Indoctrination	39
4.3 FACILITIES AND EQUIPMENT	39

5.0	COSTS vs. BENEFITS OF METRICATION.....	41
5.1	BENEFITS.....	41
5.2	COSTS.....	43
5.2.1	ADMINISTRATIVE COSTS	44
5.2.2	TRAINING COSTS	45
5.2.3	FACILITIES COSTS.....	45
5.2.4	COST CALCULATION	45
6.0	SETTING METRIC POLICY.....	49
6.1	COMPANY POLICY	49
6.1.1	Engineering	50
6.1.1.1	Drawing Preparation.....	52
6.1.1.2	Calculations	54
6.1.1.3	Material Specification	55
6.1.2	Production Trades.....	57
6.1.3	Support Trades	59
6.2	INDUSTRY POLICY	61
7.0	CONCLUSIONS & RECOMMENDATIONS	63
7.1	TABLE OF RECOMMENDATIONS	66
	REFERENCES:.....	69

APPENDICES:

- A. Executive Order 12770, Metric Usage in Government Programs
- B. DoD Instruction 5000.2
- C. DoD/Navy Metric Systems and Subsystems listed in Reports to Congress (FY '88-'91)
- D. Metrication Transition Plans & Activities of Government Agencies (selected maritime related)
- E. Metrication of USN Surface Ships, NavSea Metrics Conference, 19 February 1992, Crystal City, VA
- F. Shipbuilder Survey, with Tabulated Responses
- G. Shipbuilder Supplier Survey, with Tabulated Responses
- H. PBI Metric Training Course Outline, May 1993
- I. Metrics Reference Source Listing
- J. MIL-STD 1476B, "Metric System Application in New Design"
- K. Draft Policy Statement: Metric Usage in the U.S. Shipbuilding Industry

ACKNOWLEDGEMENTS

The project team wishes to acknowledge and thank the following persons and organizations for their support in the development of this report through their contribution of information and/or review of the the preliminary draft. No less gratitude is given to the countless unnamed others who have contributed to the study.

Alfa-Laval Marinene Power Div.
AMSCO Product Sales
Glem Ashe, American Bureau of
Shipping
Amos Baki, M. Rosenblatt & Sons Inc.

Ritter Engineering
Peter Schmidt, Marco
Mark Smith, Ingalls Shipbuidling
Ray Carrell, MTU North America
Dr. Gary Carver, National Instituti of
Science and Technology
Walt Christenson, Philadelphia Naval
S.Y.
Warren Pumps
Wascornat of America
Weksler Instruments
Joe Yurso, Q.E.D. Systems Inc.
IMo Delaval Inc.
Robert Herre, Jeffboat
Joy Technologies Co.
Ian-Conrad Bergan Inc.
KruppMaK Diesel Inc.
Chuck Lawson, Blohm & Voss
Joe Maka, Bollinger Shipyard
John Malone, NASSCO
Fred Mertz. Colton & Co.

Charlie Rahn, Nautical Designs Inc.
Dave Nelson, NavSea
Bob O'Neill, American Waterways
Shipyards Conference
Archie Nichols, Nichols Brothers Boat
Bldrs
Bill Becker, Newport News Shipbuilding
Jeff Bubm, Bath Iron Work
Tano Marine Systems Inc.
Thordon Bearings
Larry Walker, Trinity Marine Group

Derbyshire Machine & Tool

Gerry Embry, Ingalls Shipbuilding
Joe Hamilton, CDI Marine Company
Ray Francis, St.. John's Shipbuilding
Tim Donovan, European Ship Repair
B.J. Griffin, Avondale Shipyards
Jim Inman, Newport News Shipbuilding
Ingersoll Rand
Bob Keene, NavSea
Joe Langenstein, Caterpillar Corp.
George Levine, MARAD
Donna Manoli, Gibbs & Cox Inc.
Ray Mathewson, Dreadnought Marine
Frank McGrath, R.A. Steam hLC

INTRODUCTION

Today, while the vast majority of the industrialized world has adopted metric system in its industry and commerce, the U.S. still maintains the inch-pound (English) system as its basic system of measurement. While most agree upon the inherent logic and efficiency of the metric system, this alone is not likely to justify the disruptive effects of an immediate and full scale conversion. Nevertheless, it is an inescapable fact that the U.S. is dealing in an increasingly metric world with an obsolete inch-pound based system. Foreign markets, government mandates, international standards and an increasingly foreign supply base are imposing a very real form of metrication upon all of our commerce. There is no doubt that these forces will continue and intensify their influence. The key issue today is not whether American industry converts to the metric system - but when and how. For those involved in international commerce, metrication will be essential in maintaining their markets and supply base. For those not directly involved in international commerce, metrication will be felt as a secondary effect, but felt nevertheless. The key issue is how to manage the conversion process such that it minimizes the disruption of change and maximizes the benefits.

This project was initiated by Panel SP-6 (Marine Industry Standards) of the National Shipbuilding Research Program (NSRP) and contracted to Peterson Builders Inc. of Sturgeon Bay, WI to address just that issue for the shipbuilding industry. The project was not based upon a foregone conclusion that U.S. shipbuilding must do an immediate full scale conversion, but to develop an industry perspective on the technical issues of metrication and propose recommendations for addressing them. There were three final deliverables proposed for the project, this report being the primary one. The report has as its objectives:

- . Provide a global perspective of the forces and obstacles associated with metrication.
- . Define the major issues of metrication affecting U.S. shipbuilding.
- . Propose recommendations and an action plan for addressing the issues.

In addition to the report, two secondary deliverables were made part of this project to bring attention to the issues and promote dialog on them. The first is a video presentation which generally parallels the report's findings and recommendations, but in a highly digestible fashion. It was felt that the more of the industry's constituents that could be reached, the higher the level of comfort that could be obtained in making the change. It also serves as an ideal introduction to training sessions to generate workforce feedback on metrication. The third deliverable is a Metrication in Shipbuilding workshop, scheduled for presentation at the 1993 NSRP Ship Production Symposium. The workshop is

intended to reach a concentrated audience of mid and upper level shipyard management and present not only the findings of the report, but also views from other industries which have undergone metrication.

The issues of metrication were approached from two perspectives. The first was global in order to take into account current economic, political, and technical considerations as they relate to metrication in general. The purpose of this perspective was to gain a broad view of the forces influencing the issue and to exploit the experiences of other industries in their conversion. The other perspective focused upon shipbuilding's unique characteristics and tailored the observations made in the global perspective to meet shipbuilding's requirements. In order to develop the global perspective, the services of Bob Toth of R.B. Toth Associates were retained, bringing to bear years of standardization and metrication experience in various industries worldwide. Tom Soik of Soik Associates was retained to develop the shipbuilding perspective leading to the report's conclusions and recommendations.

It is the authors' hopes and expectations that the information forwarded by this report will be seriously considered by those in the industry in positions to act upon it.

M E T H O D O L O G Y

Information required for the preparation of this report was gathered through a combination of surveys, interviews (phone and on-site), and publication searches. At the start of the project, in an effort to draw in as much of the industry and interested parties as possible, press releases were sent to 81 trade publications announcing the project's objectives and soliciting support. An informal spot check indicated that approximately half of the publications actually ran the article. A contact person and phone number were included in the article and there were at least ten responses received as a result, some of which were very valuable to the project in the contacts they provided and information they offered.

The press release was followed up with a mailing of query letters to 92 shipbuilder/repairers and 208 suppliers requesting their input via a survey which would be sent at a later date. Separate surveys (Appendix F & G) were designed for the shipyards and the suppliers and sent to those which had responded to the query letters and also to about another 100 which hadn't responded in an effort to increase the size of the sample. Survey responses were received from 13 shipyards and 21 suppliers. Despite the low response rate, which limited the statistical significance of the tabular results, those surveys which were returned contained a wealth of information in the comments volunteered. The surveys were followed up with phone interviews of the respondents, especially those which had extensive experience with metric usage and/or particularly strong opinions on the issues. These contacts usually resulted in a second tier of contacts and, in some cases hard copy information.

Due to the especially low response rate of suppliers, a campaign of phone interviews was conducted to draw out information on availability of metric products. The purpose here was less to gather hard data (which was generally not available) than to get an overall tone of the supplier base. Suppliers were generally willing to discuss the {non)availability of their metric products, but it was not high on their list of priorities. Discussion of the same subject in the context of a potential sale may have made a difference.

On-site interviews were conducted with personnel from NavSea (Specifications and Standards, LX Program), two shipyards (Ingalls, Avondale) in conjunction with the LX Program Design Team, Peterson Builders, NIST (National Institute of Standards and Technology), Port Engineer for the Port of New Orleans, two design firms, and Caterpillar Corp. An opportunity was made available to address a NavSea Metrics Conference in February, '93 and solicit input from the attendees as a cooperative effort between the NSRP and NavSea. This proved to be a valuable experience in the information received and the contacts made. The

project team has, in turn provided NavSea personnel with some of its findings in advance of this report.

Peterson Builders, concurrent with this project, was in the midst of a Navy contract with hybrid metric requirements. This provided the project team the opportunity to identify issues and evaluate its findings in a real-world environment. Interactive training sessions were conducted with personnel involved with the metric contract to draw out their feelings on the conversion, the problems they encountered and the most effective approaches to them.

Finally, there is an abundance of published information (government agency publications, trade association papers and manuals, metric association periodicals) on the metric system and the experiences of other industries in making the conversion. An extensive library of reference material was compiled and scanned for relevant information for comparison to the information gathered first-hand by the project team. Of special interest were reports prepared under contract to NavSea by three shipyards (Ingalls, General Dynamics [Quincy], and Lockheed [Seabrook]) which investigated the feasibility and ramifications of a metric DDG class in 1982. Both the technical insights and the historical perspective provided by these reports were invaluable.

The project's authors met in June '93 to condense and rationalize all of the information they had gathered over the past four months into a manageable set of conclusions and recommendations which would lead to the drafting of this report. The first draft of the report was forwarded to six shipbuilder and shipbuilding related organizations for review and comment. Comments were received, resolved and incorporated into the final draft.

EXECUTIVE SUMMARY

Major findings of a study of the issues affecting the introduction of metric practices throughout the U.S. shipbuilding industry are presented in this report. The study aimed to determine how the industry's markets, supplies, and operations would be affected by the external influences driving, not only shipbuilding, but the entire national industrial base toward the metric system of weights and measures. This report identifies the forces which make conversion to metric usage necessary or desirable, identifies cultural and operational impediments to the conversion process, and proposes pragmatic recommendations for dealing with the major issues at both the individual shipyard and industry levels.

This report is the result of extensive discussions with individuals in industry and government who are actually involved in metrication, as well as members of the marine industry with and without experience in metrication. Surveys of shipbuilders and suppliers provided valuable insight on the perceptions and experiences of these sectors. These views became the basis for further investigation and discussion.

FINDINGS:

Congress has determined that it would be in the best interests of American industry to promote metrication so that it can compete effectively in global markets. Government agencies are obligated to implement the law (p.L.. 100-418) which, among other actions directs them to specify government requirements in metric units in all procurements and to promote the purchase of metric products. As a result, it is NavSea policy that, while there is no intent to drive yards and suppliers by requiring redesign to metric dimensions, new designs will utilize metric practice to the extent that performance requirements are met and no significant cost, schedule, or technical risk is involved. Other government agencies with marine interests ranging from the U.S. Coast Guard to the St. Lawrence Seaway Development Corporation are implementing metrication programs.

An overriding consideration, however is the global reality that the U.S. is an inch-pound island in a metric world. By resisting change to the metric system, the U.S. is, in effect imposing a trade barrier on itself.

The decision to convert to metric practice at individual shipyards will be based primarily on the existing or potential markets for their products as summarized on the following page.

MARKET	PRODUCT	MEASUREMENT
U.S. Gov't/Military	New Classes, subsystem designs	Metric ¹
" "	Follow ships of existing designs	Inch-pound
Foreign Military Sales	Combatants, patrol craft, aux's	Metric ¹
Commercial, Jones Act	Tankers, containerships, product carriers, etc.	Inch-pound
Commercial, non-Jones Act	Tankers, containerships, product carriers, etc.	Metric ²
Commercial, Inland, Coastal	Tugs, barges, ferries, supply boats, specialty craft	Inch-pound
Repair/Conversion	All	Most expedient

¹ Hybrid products for the foreseeable future with many subsystems and components in inch-pound configuration.

² Unique or proprietary designs of highly specialized vessels will be less likely to be affected.

The U.S. Navy and other government customers will be major drivers to the industry's move toward metric usage. Commercial shipbuilding and repair, especially for inland and coastal vessels will be substantially less affected, but will feel a secondary affect as the supply base gradually becomes metricated. While the metric system's inherent simplicity and worldwide acceptance could enhance the marketability of products and services, cost and delivery will have a more profound effect on the potential customer's buying decision. Metrication will be influential to the extent that it simplifies design practices and contributes directly to the reduction of operational costs. The potential savings and cost avoidance which could be realized in the near-term are of a discrete nature and do not lend themselves to finite calculation, although experiences of manufacturers which have undergone metrication indicate generally positive results. Long term, the major driving force will be less internal savings than the fact that it will become more difficult to maintain inch-pound based shipbuilding in the face of increasingly metric market demand and supply availability. The report recommends that decision-making be based on these long term considerations.

Most of the basic materials used to build ships are readily available as metric products, although a shipyard may have to expand its search beyond its traditional suppliers for some. Most major equipment is also available in metric though the sources may be foreign or U.S. licensed manufacturers of foreign designs. A large body of metric standards exist if industry and its U.S. customers look beyond domestic documents to the international and national marine standards which are used widely in the rest of the world.

This report delineates the steps which should be taken to train design staff and yard personnel and adapt production facilities. It points out that special

attention needs to be given to metric application where safety could be adversely affected, such as pressure gauges and the maximum ratings of material handling equipment.

A model for determining the costs of metrication is presented. The costs of administration, training, and facilities are estimated in relation to the number of employees directly charged to a metric contract. This enables the model to be applied in the most typical situation where metric and nonmetric contracts coexist at the same yard. Using widely accepted cost factors and assuming the manning requirements for a contract valued at \$40 million, it is estimated that non-recurring additional expenditures attributable to a hybrid metric design for a lead ship would be in the range of 1- 1 ½ % of the contract value. **This value assumes that metric materials and components are procured at cost and delivery on a par with their non-metric equivalents, which, of course may not always be the case.** The report recommends in those cases where metric supplies are significantly higher in cost and/or delivery times that technical and economic considerations take precedence over metric considerations. This cost projection is at variance with other analyses as it is based on the premise that "metrication will be accomplished where it can be done reasonably", rather than "metric at any cost". The methodology of the approach to cost estimating is a reflection of NavSea's metrication guidance which will result in hybrid metric ships for the foreseeable future.

The shipbuilding industry and individual yards must address a number of issues and challenges as they determine whether to metricate and, if so, how fast. A series of recommended actions are presented for individual shipyards which constitute a plan for implementing metric practices for a project or throughout the yard. The first and most critical step is to define the yard's metric policy, taking into account its markets and other forces.

It appears evident that metric requirements will have increasing impact on the shipbuilding industry as Congress' and the Executive branch's mandates are implemented by U.S. government agencies which purchase the products of this industry. To enable individual shipbuilders to share experiences, communicate effectively with their customers and suppliers, and define a cost-effective, rational path to metric design and construction, it is recommended that the NSRP facilitate the establishment of a Shipbuilding Metrication Policy and the mechanisms necessary to implement it. The draft of a policy (Appendix K) is proposed as a "strawman" to enable deliberations to get underway as soon as possible. It is recommended that a Shipbuilding Metrication Council be established to serve as a **forum to address some of the critical issues identified in this study and serve to coordinate among the various sectors within the industry, particularly between the yards and U.S. government agencies.**

1.0 THE METRIC BACKGROUND AND

CURRENT STATE OF AFFAIRS

1.1 BACKGROUND

While the basis for the metric system was originally proposed in 1670 it was not until 1790 that formal action was taken by the French National Assembly to adopt it. The new measurement system was not widely accepted within France and in 1812 Napoleon legalized return to pre-metric units. In 1840 France mandated that the metric system be used throughout its territories.

President Thomas Jefferson proposed to Congress in 1790 that the U.S. adopt a decimal-based measurement system and in 1821 President John Quincy Adams recommended adoption of the metric system. In both instances Congress was reluctant to adopt a measurement system different from its primary trading partner, Great Britain. The federal government took no formal action on metric until 1866 when its use as a measurement system was legalized. In 1893, all standard U.S. measures were defined in terms of metric units. In 1902, Congressional legislation requiring the federal government to use metric exclusively was defeated by just one vote.

Many countries began using the new metric system during the second half of the nineteenth century. Prominent exceptions in addition to the United States were members of the British Commonwealth. England, Canada, Australia, India, and other countries in their spheres of influence did not change to metric for fear it would interrupt their thriving trade operations. Nevertheless the United States and United Kingdom joined with 15 other nations in 1875 to sign the Meter Convention (Treaty of the Meter). This treaty established the International Committee for Weights and Measures, with its General Conference, and International Bureau as the mechanisms to "... ensure worldwide unification of physical measurements. " The International Bureau of Weights and Measures maintains the primary physical standards and

"Weights and measures may be ranked among the necessities of life to every individual of human society. They enter into the economical arrangements and daily concerns of every family. They are necessary to every occupation of human industry; to the distribution and security of every species of property; to every transaction of trade and commerce;...to the navigation of the mariner..."

**John Quincy Adams
Report to Congress, 1821**

calibrates the standards of its signatory nations. In 1991 there were 46 members of the Convention.

Prior to 1960 there were a range of measurement systems based upon metric units which had evolved over the years and had been implemented in various regions. These included:

- Ž CGS -- centimeter-gram-second, defined in 1873 and widely used in the teaching of physics and chemistry
- MTS -- meter-tonne-second, used in France from 1919 to 1961
- Ž MKS -- meter-kilogram-second, widely used throughout Europe even to the mid-1980s
- MKSA -- meter-kilogram-second-ampere, adopted in 1950; combined mechanical and electrical units in a coherent system.

By adding the base units kelvin, candela, and the mole, to the MKSA system the General Conference established the world's first comprehensive, coherent, practical system of measurement. It was designated *Le Systeme Intefnationale d'Unites* with the abbreviation SI.

In the context of global trade, the modern metric system is more than just SI. It includes the product standards and preferred sizes that are accepted by industries and governments throughout the world.

1.2 U.S. INITIATIVES

The U.K began converting in 1965, prompted not only by perceived benefits of metrification, but as a pre-condition to membership in the European Community.

The scientific, technical and educational benefits of the new SI system were recognized throughout the world and an almost spontaneous world movement toward the adoption of SI resulted. The United Kingdom began converting in 1965, prompted not only by perceived benefits of metrification but as a pre-condition to membership in the European Community. Australia converted during the period 1970-1982, and Canada went as far as it could between 1971 and 1984 given its interdependence with U.S. markets.

A three-year study by a 45 person advisory panel to the U.S. Department of Commerce concluded in 1971 with publication of the report "A Metric America, A Decision

Whose Time Has Come." It described the United States as an island in a metric world. Congress passed the Metric Conversion Act in 1975 which called for voluntary conversion. The law established an independent Metric Board. After a ten-year transition it was expected that SI would be the predominant measurement system in America. However, the Board failed to distinguish the economically urgent industrial change to metric from the far less urgent need for social metric change. Arguments about lost export markets got mixed up with adoption of metric road signs. The general public resented what seemed an unnecessary social nuisance. Lacking support from the American public, the Metric Board told Congress it could effectively promote the change to metric only with a congressional mandate and this was not forthcoming.

The Metric Board was disbanded by order of President Reagan in 1982. As its final task the Metric Board summarized its findings on the challenges and status of metrication for U.S. industry and consumers. These 1982 findings are summarized on the following page.

Some of the Board's functions were continued on a very limited scale within the Department of Commerce. With no deadline to move into the metric world, U.S. metric conversion was paced by the initiatives of the Department of Defense and major companies, mostly with international interests, facing the challenge of staying competitive with foreign firms. Statistics developed by the Department of Commerce in 1987 showed that an estimated 25 percent of U.S. manufacturers were metric and more than 60 percent of Fortune 500 companies produced at least some metric products in contrast to between 10 and 20 percent in the early 1970s.

The Department of Defense has maintained a proactive metric stance since the late 1970s. A major consideration has been the need to support equipment jointly with our NATO allies. In 1980 DoD directed that the Services develop a "complete spectrum" of metric standards and specifications by 1990. At that time it was assumed that the U.S. would be predominantly metric by

(Overheard at U.S. State Dept.) Some foreign nationals were visiting the State Department and observed the department's National Metric Week exhibit. One of the nationals asked a colleague, "Why do they have a metric system exhibit?"

His colleague responded, "Didn't you know? The U.S. will be using metric units after 1992."

With a puzzled look, the man said, "Really? What have they been using?"
from Metric Today, Mar '92

METRIC BOARD FINDINGS:

The following findings were published in July 1982 as part of the Metric Board's retrospective look at what it had learned over the previous four years about metrication in the United States.

-
- The present policy of maintaining a dual system of measures for trade and commerce is confusing to all segments of American society.
 - Some segments of the economy have been metric for decades, others will convert for economic or marketing reasons, and some will probably never change voluntarily. Total conversion is practical for certain parts of the economy.
 - Voluntary metric conversion by industry occurs primarily in response to marketplace demands and usually on a company by company basis.
 - Business converts when it wants to penetrate or maintain international markets, when it sees a marketing advantage in producing metric products, and when it wants to gain or keep customers who are converting to metric for their own purposes. Plans for industry-wide metric conversion appear to have little or no influence unless economic motivation is already present.
 - The costs of metric conversion have not been excessive.
 - Large corporations' conversions have resulted in long-term savings; small business conversions have usually been made at low cost. This supersedes and corrects the findings regarding costs in the October 1978 GAO report, "Getting a Better Understanding of the Metric System - Implications if Adopted by the United States".
 - Large segments of industry have metric capability.
 - More than half of the Fortune 1000 companies have metric production capability. Small business has a widespread but shallow capability to produce metric products. When conversion problems occur, the small business community solves them by using its own resources.
 - Past perception of the difficulty of metric conversion have no basis.
 - There is convincing evidence that fears of huge expenses and other insurmountable problems with conversion are groundless.
 - There are no substantial legal barriers to metric conversion requiring Federal preemptive action.
 - There are not substantial technical problems with metric conversion.

- Complex problems that are perceived in metric conversion have not been substantiated. Standards-making organizations are able to respond to industry's metric needs.
- The labor force has little difficulty adapting to conversion.
- Minimal training in metric measurement is needed to sustain efficiency and safety. Some workers, however, incur expenses in buying metric tools.
- Consumers accept conversion according to their own interests.
- If economic necessity or advantage is foreseen by consumers, conversion is more likely to be accepted. Resistance at the retail level, however, can be expected because of consumer inertia, lack of understanding, and perceived inconvenience.

the end of the decade. To foster greater interoperability and standardization with allies, DoD revised its Directive 4120.18 in 1987 to require among other things, that S1 be used in all systems requiring new design unless justified as not in the best interest of DoD. The directive also emphasizes the need to develop metric standards, specifications, and technical data.

1.3 GOVERNMENT REACTION TO GLOBAL DEVELOPMENTS

Since 1975 several international developments have changed the conceptual framework which was the basis for drafting the Metric Conversion Act

- . All of our non-metric trading partners including the U. K., Canada, Australia, and China completed conversion to the metric system;
- . Business and trade evolved into a global economy;
- . International standards have become an important factor in international economic competition, and
- . Economic strength began to have more impact on world affairs than military strength.

By the mid-1980s the U.S. was the only industrialized nation that had not converted to the metric system. At this point too the U.S. was experiencing unprecedented trade imbalance. Congress concluded that there was a direct relationship between metric specifications for products and their export potential. By resisting change to the metric system, the U.S. was in effect imposing a trade barrier on itself.

Congress concluded that there was a direct relationship between metric specifications for products and their export potential. By resisting change to the metric system, the U.S. was in effect imposing a trade barrier on itself.

Congress addressed the competitive importance of metric measurement by including provisions for metric usage in the Omnibus Trade and Competitiveness Act of 1988. This legislation (P.L. 100-418) recognizes that

- . World trade is increasingly geared toward the metric system of measurement;
- . U.S. industry is often at a competitive disadvantage when dealing in global markets because of its non-metric measurement system.

This Act amends the Metric Conversion Act of 1975 by designating the metric system of measurement as "the

preferred system of weights and measures for U.S. trade and commerce";

- . Specifying that "metric" means the modernized international system of units, SI;
- . Requiring each federal agency to implement metric usage in grants, contracts and other business-related activities, to the extent economically feasible, by the end of fiscal year 1992; and
- . Requiring each federal agency to establish guidelines to implement the policy and report to Congress on progress.

Many federal agencies initiated metric conversion programs, but others found reasons not to do so. One problem was that the legislation has no statutory provision for leadership and coordination of the overall transition effort. This was corrected in July 1991 with the issuance of Executive Order 12770, "Metric Usage in Federal Government Programs." See Appendix A. The Executive Order gives specific direction and new management authority to the Secretary of Commerce to lead and coordinate implementation of metric provisions in the Omnibus Trade and Competitiveness Act. The amended Metric Conversion Act of 1975 and the 1991 Executive Order provide both the rationale and mandate for a transition to use of metric units.

The rationale is the need to remove a trade impediment to U.S. products, as well as to improve efficiency and competitive advantage. It recognizes that a metric changeover can make the U.S. economy stronger by helping industry access global markets and decrease multibillion dollar trade deficits. The 1992 deadline for full implementation within federal agencies reflects concerns about establishment by the end of 1992 of the world's largest free market within the European Community. A key element of the EC's drive for a common market is harmonization of various national standards into European norms. Congress took into account that the metric standards being adopted by the EC could be an effective tool for discrimination against U.S. products produced in inch-pound units.

Congress took into account that the metric standards being adopted by the EC could be an effective tool for discrimination against U.S. products produced in inch-pound units.

The mandates in the law and the Executive Order call for the Federal Government to:

- Use the metric system in procurements, grants, and other business related activities (with some exceptions allowed);
- Use metric units in government publications as they are revised on normal schedules or as new publications are developed;
- Work with trade, professional, and private sector organizations on metric implementation;
- Increase understanding of the metric system through education and guidance; and
- Use the metric system in measurement-sensitive programs and functions relating to trade, industry, and commerce particularly in government procurement.

These mandates are intended to be the catalyst for U.S. industry to complete its transition to the metric system. The Federal Government uses measurements in many ways that influence through regulations, data collection, publishing, and other areas. As the largest customer of U.S. industry, procurement is the primary federal tool for encouraging industry to convert. The direct financial incentives to sell to the government are proving to have a positive influence on industry.

Metric implementation is being accomplished cautiously but realistically. The question is not whether to implement metrication but when and how.

The Metric Conversion Act allows exceptions to avoid giving advantages to foreign firms. Exceptions are permitted where the metric system is "impractical or is likely to cause significant inefficiencies or loss of markets to U.S. firms." Agencies have different views and some uncertainty on the pace of transition, their leadership responsibilities, and level of proactivity they can or should exercise. Agencies that buy from suppliers who are not already converted are reluctant to use metric units or request metric products. Metric implementation is being accomplished cautiously but realistically. The question is not whether to implement metrication but when and how.

Only new projects are to be accomplished with metric units. Existing projects are not going to be changed. Reduced budgets are limiting the number of new projects and therefore constraining the pace of transition in most agencies. Other constraints include safety considerations,

transition costs, and capabilities of existing support infrastructure.

While it is mandatory that federal agencies use the metric system, its use by industry is voluntary. The federal government is not forcing universal use of metric measurements or changes to products to meet metric standards. It is industry's choice to weigh the costs and the benefits, the disadvantages and advantages, and make its own decision.

It is industry's choice to weigh the costs and the benefits, the disadvantages and advantages, and make its own decision.

2.0 ACTION OF GOVERNMENT AGENCIES AFFECTING MARINE INDUSTRIES

2.1 THE NAW COMPLIES WITH EXECUTIVE ORDER 12770

It was noted in Section 1.2 that DoD has been a pro-active metric advocate since the 1970s. Its motivation was based primarily on the need to interoperate effectively with our allies particularly in being able to tap their stocks of spares and material in times of emergency. Another consideration was to adopt and integrate foreign weapons systems and equipment into the Armed Services. The Omnibus Trade and Competitiveness Act established as a national objective the transition to the metric system so as to expand markets for American products. This is consistent with DoD's push for "dual-usage technology" and "defense conversion." Unlike most federal agencies, DoD had a metric policy, guidelines, and transition plan in place prior to the Trade and Competitiveness Act or Executive Order 12770. In February 1991 DoD consolidated and simplified its metric policies and procedures into Part 6, Section M of DoD instruction 5000.2. These policies and procedures are reproduced in Appendix B of this report. However while DoD policies and procedures were in place, only a few major new programs, notably the Strategic Defense Initiative and Comanche {LHX} Helicopter, were fully metric.

The Navy limited its new mem-cation projects to boats, ancillary systems, and systems and subsystems derived from existing, usually foreign designs. Appendix C lists all the metric systems and subsystems reported to Congress by the Navy for FY 1988 through FY 1992. These are in various stages of development ranging from R&I to production. Most of these systems have been authorized to use existing non-metric components or nonmetric world standards.

In November 1991 the Naval Sea Systems Command (NavSea), in accordance with provisions of DoD

"With the world becoming smaller through creation of more multinational corporations, increasing international trade and exchange of publications and documents, metric is more efficient and less expensive....The choice became to either take the initiative and plan and exercise some control over the way things are done or have the system forced upon the United States."
*John Tascher, Chmn,
DoD's Metrication
Steering Group*

Instruction 5000.2, requested the Undersecretary of Defense for Acquisition to waive requirements that the LX Amphibious Assault Ship be a metric design. The LX was the largest NavSea project being initiated at the time. Instruction 5000.2 requires, among other things, that the metric system be used in all those elements of new defense systems requiring new design. Except for the derivative T-45A NavAir Trainer, most major Navy programs had requested, and were granted, waivers to the metric requirement.

The NavSea request for waiver was submitted just a few months after President Bush signed Executive Order 12270 which gave more focus and impetus to metric conversion by using the government's purchasing powers. NavSea was requested to fully justify its proposal to use conventional rather than metric units for the LX. Some of the salient arguments raised by NavSea are summarized here. They articulate very concisely most of the concerns that both the private and public sectors of the industry have about metrication.

"Extensive metrication of the LX has the very real potential to cause production delays and increase program costs."
from NavSea Request for Waiver from LX metric requirements

1. Metrication of hull and structural design is not feasible because of

- a. program complexities,
- b. austere budget environment,
- c. manpower constraints, and
- d. schedule risks.

NavSea did state, however, that every effort would be made to incorporate metric components, systems and subsystems.

2. LX is vitally needed to meet strategic objectives. Schedule delays would affect the force structure and extensive metrication has the potential to cause delays.

3. While the ship design community has some degree of experience in metrication, earlier metric projects (LSD 41 and DDG 51) reverted to inch-pound when projected costs became prohibitive. A NavSea analysis estimated that LX end costs would increase 12.6 percent.

4. Extensive rewrites will be required of design and engineering specifications and standards, and related computer software.

5. There has been no appreciable commitment by the shipbuilding industry to adopt the metric system. Even with a willing and responsive industry, the confusion of producing ships of different design (metric and conventional) will increase the human factor for mistakes in quality control and workmanship.

6. The shipbuilding industry would require extensive training involving many man-hours.

Congress and the President recognized that action was necessary to break the closed-loop syndrome: Suppliers offer either what they perceive is desired by their federal customers or what they can easily produce; federal agencies then are reluctant to request metric products because suppliers have not converted. This is exemplified in the concluding paragraph of the NavSea justification.

Previous efforts to execute a total metric design were, on the whole unsuccessful due to costs and resistance to force change upon the shipbuilding industry. One of the key components of metric directives is that the metric system shall be adopted by DoD in "areas where industry has made significant progress in the design and production of metric products." It is our contention that such progress has not been made in the shipbuilding industry.

DoD's response accommodated some of NavSea's arguments but indicated there was less leeway in granting waivers now that amendments to the Metric Conversion Act in the Omnibus Trade and Competitiveness Act were the law (15 USC 205).

We still do not believe that a convincing case has been made to justify a waiver. We are not insisting that the LX be an "all-metric ship." However, we believe that a "hybrid" ship -- i.e., some subsystems in metric design and some in inch-

One of the key components of metric directives is that the metric system shall be adopted by DoD in "areas where industry has made significant progress in the design and production of metric products." It is our contention that such progress has not been made in the shipbuilding industry.

pound design, with proper interfaces -- is both attainable at a reasonable cost, and the only configuration which will comply with the provisions of 15 USC 205. The Omnibus Trade and Competitiveness Act of 1988 requires that all federal government procurements made after September 30, 1992, use the metric system unless doing so is impractical. The documentation provided by the Navy does not demonstrate that it would be impractical for the "new design" portions of the LX to be metric.

"The documentation provided by the Navy does not demonstrate that it would be impractical for the "new design" portions of the LX to be metric."
from DoD response to NavSea Request for (metrication) waiver

DoD's response also made the following points:

1. Many subsystems and components would be Non Developmental Items; i.e., previously designed for another ship class or commercial off-the-shelf items. Those produced in inch-pound do not have to be changed.
2. Many specifications, standards, design data, and software are already available in metric.
3. New systems and subsystems should be metric since they will require LX-unique material, tools, dies, etc. If those have to be designed "from scratch" they can just as easily be designed in metric.
4. Any incremental costs for metric training and conversion of documents and data would be small in comparison to total design and construction costs.
5. NavSea had not provided evidence that using metric for the "new design" portion of the ship is more likely to cause a schedule slippage than other aspects of the program.

With this, NavSea committed the design development of the LX to the metric system. In support of their metric initiatives, they have issued a "Metric Guide for Naval Ship System Design and Acquisition". As a means of drawing the shipbuilder community into the transition, Navsea conducted a Metrics Conference and interviews at shipyards to inform shipbuilders of the pending transition and solicit their input to the metrication process.

NavSea not only incorporated metric requirements in the LX, but the Secretary of the Navy (SECNAV) issued Instruction 5000.2A in December 1992, which invokes DoD Instruction 5000.2 within the Navy and makes COMNAVSEA responsible for Navy participation in the DoD metrication program.

2.2 OTHER GOVERNMENT INITIATIVES AFFECTING MARINE INDUSTRIES

The metric initiatives of other federal agencies directly affecting marine industries are summarized here.

2.2.1 Coast Guard

The U.S. Coast Guard has constructed 37 fully metric Island-Class patrol boats. Among other equipment, rigid-hull inflatable boats carried on the Island-Class and similar boats are designed to metric specifications as is the MK 75, Oto Melara 76mm high speed cannon and 25mm machine gun. The Coast Guard's metric conversion plan is based on 13 operating tasks, each with organizational provisions, actions, schedules and responsibilities. One of the initial tasks scheduled for completion by October 1993 is development or conversion of requisite metric procurement specifications and standards. A Metrication Handbook is to be available also by October 1993.

2.2.2 Maritime Administration (MARAD)

To accommodate metric construction in the U.S., MARAD will complete a metric version of the Standard Specifications for Merchant Ship Construction by July 1994. It is developing a list that will differentiate metric-built ships from inch-pound built ships to facilitate replacement part tracking; compile an inventory of ships whose fathometers are inch-pound only and target their replacement; and include in all in-house, contractual, and cooperative study solicitations a provision for utilizing metric units in the final report.

"Through their actions, federal agencies are demonstrating an increasing determination to use the metric system of units in business-related activities. The results are not yet very visible to the public, which is not a direct target of current federal transition activities. Industry is the target, and is becoming increasingly aware of and generally welcomes the government's progress."
from "AMetric America: A Decision Whose Time Has Come - For Real", National Institute of Standards & Technology

A comprehensive metric transition plan has been developed and is being implemented by MARAD. Significant elements of the plan include:

Shipbuilding. This element involves the conversion to the metric system in four sub-areas: Data collection and dissemination; development of published guidelines; assistance for building ships; procurement of new ships and conversion work.

Research and Development. Since 1992, all research reports have been published using both inch-pound and SI units; by 1997, all research reports will be published in only metric units.

Ship Operations This program area involves metric conversion for the following sub-areas; ship repair, ship activation and deactivation; ship operations, ship-related services; ship acquisition.

Market Development. Two statistical databases under the Office of Market Development use the metric system: National Cargo Shipping Analysis System and Ocean Freight Differential System.

Port Development. All contractual studies on improved port planning, productivity enhancement, and facilitation of commerce will be published using only metric units; the Maritime Statistical Information System will be reviewed for metric usage.

Maritime Aids--Ship Subsidy Programs.

Measurement characteristics are being converted to metric in Ship Financing, Construction Reserve Fund, Capital Construction Fund, Construction Differential Fund, and Operating Differential Fund applications and related publications as well as the conversion of all other Maritime Aids publications such as the Financial Report Form MA-172, and vessel and trade publications.

" recognizing that transition is inevitable, it is imperative that actions be planned and executed to assist the industry transition in being efficient and economical. Transition efforts will be encouraged and supported wherever possible."
MARAD Metric Transition Plan, 1992

2.2.3 U.S. Merchant Marine Academy

Students at the Merchant Marine Academy are receiving instruction in the metric system in the areas of

math and science and especially in physics and chemistry. Because at this time the National Accreditation Board for Engineering and Technology (ABET) requires that all instruction in the engineering area be conducted using the both measurement systems, textbooks discuss issues and contain problem sets involving both inch-pound and metric dimensions. Since an increasing number of metric vessels are being introduced into the fleet, shipboard training and preparation for the "sea year" involves continuing metric indoctrination. Similarly, as the navigational charts are converted to the metric system, additional training will be conducted. The Academy intends to purchase its military uniforms according to metric sizes.

2.2.4 National Oceanic and Atmospheric Administration (NOAA)

The United States is the only nation producing nautical charts in feet and fathoms. NOAA's Coast and Geodetic Survey has started to convert to the metric system all of its 992 nautical charts of the territorial waters of the U.S. and its possessions. In 1993 charts for the San Joaquin River and Louisiana waters will be converted. Chart revisions will pick up as the agency's Automated Nautical Charting System II becomes operational in 1994. NOAA is adhering to the following general policies as it metricates:

1. Safety of navigation will continue to be of primary importance.
2. Every effort will be made to convert charts in logical groupings so that mariners' transits will require minimal shifting between the two measurement systems.
3. Conversion will be a multi-year-year effort with implementation expected in 10 to 15 years.

Metric conversion will not affect use of the international nautical mile (1,852 m or 6,076 ft) for distances at sea or the use of the knot for speed, at least for the foreseeable future.

NOAA has begun public education through brochures, meetings with affected interests, and announcements in Local Notices to Mariners. Nautical charts being printed now also have a metric conversion

Metric conversion will not affect use of the international nautical mile (1 852 m or 6,076 ft) for distances at sea or the use of the knot for speed, at least for the foreseeable future.

table near the title box for those who want to begin getting used to metric equivalents.

Saint Lawrence Seaway Development Corporation (SLSDC)

Since 1975, water flows, water levels, water temperatures, and ice thickness in the Saint Lawrence Seaway have been recorded in metric units as requested by the International Joint Commission. In addition, water usage and regulated data have been in metric units since that date. In 1977, the Corporation converted its operational activities to the metric system. Accordingly, the Seaway Regulations and notices to mariners have been published using metric units. The affected measurements are: cargo volumes, vessel dimensions, vessel drafts, lock dimensions, mileage markers, bridge signs, and lock wall markings. In addition, the navigation charts for the seaway have been converted to metric units by the National Ocean Service of NOAA and Canadian Hydrographic Services.

In 1992 the SLSDC started writing procurement specifications using a dual system with inch-pound taking the primary position. In 1993 metric is entered in the primary position. Starting in FY 1994, if no major problems are encountered, metric-only measurements will be used.

2.2.5 Federal Maritime Commission

For the most part, metric units are being introduced into procurement on an evolutionary replacement/substitution basis. However, major new starts represent a very small portion of the ongoing procurements.

The main impact of the Federal Maritime Commission on the maritime industry is in the Commission's procurements and in tariff conversions. Its metrication program recognizes that the U.S. is an island in a metric world as the U.S. attempts to computerize tariff filing and publication. The Commission is cooperating with the desires of the appropriate sectors of the international shipping enterprise.

2.3 ASSESSMENT

The initial efforts of most federal departments and agencies to "go metric" have focused on internal policies,

guidelines, and administrative arrangements. It can be seen from the accounts in this chapter that many agencies affecting marine interests have proceeded beyond that stage to more wide-spread implementation which will have an effect upon industry. For the most part, metric units are being introduced into procurement on an evolutionary replacement/substitution basis. However, major new starts represent a very small portion of the ongoing procurements. Another consideration is DoD's push for the re-use of nondevelopmental items and dual-usage commercial items. Most non-defense agencies generally purchase commercially available products and technologies. While the 1992 target date of Executive order 12770 has passed, many federal agencies are still not in a position to procure metric products. It is also difficult for industry to know how and when it must respond to government requests for metric products and services. It has been suggested that government and industry work together in a user/supplier consultative process for the purpose of establishing achievable dates for supplier conversion to metric design and manufacturing standards. The commercial construction industry is participating in a cooperative coordination program with the General Services Administration, Navy Facilities Command, Corps of Engineers, and other agencies responsible for a \$40 billion annual expenditure for federal construction. Together, public and private sector groups representing architectural and engineering firms, prime contractors, subcontractors, materials suppliers and standardization specialists are determining the "what, how, and when" of metric transition for construction.

Current initiatives to metricate are benefiting from lessons learned by the short-lived Metric Board. There is no concerted organized movement at this time to convert the American public to metric. It is believed that the introduction of metric units to the general environment will evolve only as it becomes economically and socially logical. The approach is not to confuse the issue by getting the general public all stirred up by such secondary matters as metric weather reports, highway signs, and cooking utensils.

It has been suggested that government and industry work together in a user/supplier consultative process for the purpose of establishing achievable dates for supplier conversion to metric design and manufacturing standards.

It is believed that the introduction of metric units to the general environment will evolve only as it becomes economically and socially logical.

All our international trading partners predominantly produce, consume, prefer, and frequently require metric products. It remains to be seen whether the U.S. shipbuilding industry accepts these objectives and premises as fully applicable to its operations and aspirations.

Federal agencies are periodically reminded that the long range objective of the Amended Metric Conversion Act and its complementary Executive Order is not to convert the government to the metric system, and not to convert government contractors, but rather to enable U.S. industry, workers, and citizens to share the benefits of competing effectively on a global scale. The premise of the metric usage amendments in the Trade and Competitiveness Act is that the quality of life of U.S. citizens depends more than ever before on the ability of U.S. firms to hold onto the domestic market while penetrating growing markets worldwide. Metric usage is seen as aiding in achieving that goal by enhancing this country's ability to compete successfully in the world. If the U.S. is to participate as a leader, or the leader, in ever-changing global markets, it must produce affordable quality products, and products which other people and other countries want. All our international trading partners predominantly produce, consume, prefer, and frequently require metric products. It remains to be seen whether the U.S. shipbuilding industry accepts these objectives and premises as fully applicable to its operations and aspirations.

3.0 METRICATION - U.S. SHIPBUILDING

PROSPECTS

3.1 OVERVIEW

As demonstrated in the previous section, the global and domestic forces influencing U.S. industry toward metrication are substantial. From the "global" realities presented in Sections 1 and 2, two general conclusions are derived which have undoubtedly led to the initiation of this project and must be maintained as a foundation in the development of the industry internal issues and recommendations. The conclusions are:

1. There are significant forces which are driving U.S. industry, especially manufacturing, toward metrication. Most visible is the U.S. government's executive level mandates which prescribe a plan and schedule for converting federal procurement to the metric system. Less visible, but certainly as significant is the world market which has adopted the metric system as its standard of measurement in conducting international trade. These forces may be considered annoyances or inconveniences at present, but the forces' influence upon U.S. commerce will intensify through the end of the decade.
2. The U.S. and almost all of its commerce is currently dealing in a "hybrid" metric environment - a constantly varying and inconsistent mixture of inch-pound and metric measures. Caught in this murky gray area of measurement standards, U.S. manufacturing is paying a significant penalty in dual inventories, rework, and general disruption due to the continuous conversions between the systems.

3.2 INDUSTRY ISSUES

Hard technical and economic data concerning metrication on an industry-wide scale is very limited in its availability and its relevance to the shipbuilding industry. Most of the information available on the subject is anecdotal in nature, usually concerning organizations that

There are significant forces which are driving U.S. industry, especially manufacturing toward metrication.

The U.S. and almost all of its commerce is currently dealing in a "hybrid" metric environment - a constantly varying and inconsistent mixture of inch-pound and metric measures.

have taken a proactive approach (maintenance of the status quo gets little attention). These case studies are almost universally positive in tone, leading to the oversimplified conclusion that a highly proactive approach to metrication will produce more positive results than a more conservative one. Unfortunately, no hard data exists which would lead one to a cause and effect relationship between an organization's policy on metrication and its economic health nor is such an approach viable for a diverse set of industries. This report's main objective is not to prescribe a formula for the wholesale adoption of the metric system, but the determination of the optimum approach to the issues of metrication for U.S. shipbuilding. In pursuit of that objective, the realities both within and external to the industry must be acknowledged and addressed.

"Current customer requirements do not reflect an urgency to convert to metrication, but a substantial negative effect would result if a rapid increase in customer requirements is ahead of in-house preparation for transition."
Comment from Survey of Shipbuilders

Armed with the general conclusions from Section 3.1, specific issues within the industry can be analyzed in order to develop a rational approach to metrication. For the purposes of organization, issues have been categorized into four main groups: market demand, supply availability, workforce Training, and facilities/equipment. Within each of these groups are to be found every facet of the shipbuilding process that may be affected by a transition to the metric system. These will be dissected and analyzed in the context of the current industry environment in the process of developing specific conclusions and recommendations for the industry.

3.3 MARKET DEMAND

The value of work (newbuildings, repairs, and conversions) delivered by U.S. shipbuilders in 1992 was \$11.4 billion¹ (references are listed at the end of the report), a decrease of 1 percent from 1991. The projected value of work to be delivered in 1993 is expected to decrease by about 3 percent in constant dollars. Market projections over the next five years are generally flat to negative, given the current situation of a drastically reduced Navy shipbuilding budget and U.S. shipbuilders' lack of penetration into the international markets. However, when analyzed in closer detail, the forecast becomes a mixed bag of negatives and positives for the various market niches. For the purposes of discussion of metrication, the market

will be broken down into four general sectors:
Government/Military, Commercial - Oceangoing,
Commercial - coastal/inland, and Repair/Conversion.

3.3.1 Government/Military New Construction

The key player in this sector is the U.S. Navy, whose shipbuilding budget since 1980 of over \$100 billion has dominated the workload of U.S. shipyards. However, as a consequence of easing world tensions and a severely diminished budget, the Navy's program of new construction will be sharply reduced during the remainder of this decade. The Navy's FY '93-'97 plan² calls for construction of 35 new combatants and T-Ships with a contract value to shipyards of about \$11 billion. In addition, a yet to be determined number of Sealift ships are planned.

Of the 35 projected ships, at least 30 (CVN, DDG, LHD, MCM, T-AGOS, T-AGS) can be considered follow-on construction based upon pre-1 993 (inch-pound unit) specifications and designs. Indications from NavSea are that existing classes and the Sealift ships will not be specified in metric units, although metric components and subsystems will be "encouraged" wherever cost and schedule and class standard equipment are not affected.

The LX program is the first major Navy ship construction project to be fully affected by the federal metrication mandates. Previous smaller projects (PHM, MHC) were conducted in metric units, but their motivation was due more to experimentation and foreign design rather than operational mandates. The LX will be a hybrid metric design which, according to NavSea's interpretation is, "A design where some components and/or systems are metric and some are inch-pounds". In real terms, NavSea has preliminarily defined the ship's metric/inch-pound make-up as follows (See Appendix E for the complete directive):

The LX program is the first major Navy ship construction project to be fully affected by the federal metrication mandates.

1 STRUCTURES

- . Hull & Superstructure: Hard metric dimensions
- 1 Plate: Hard metric dimensions
- . Structural Shapes: Standard (AISC) Shapes with soft metric dimensions

- **EQUIPMENT & SYSTEMS**

- . The use of Non-Developmental (Commercial standard) Items is encouraged. The conversion of such items to metric configuration will not be required.
- . New equipment/Systems will be metric provided there is no issue of exclusion of domestic sources and there is no significant cost, schedule, or technical risk.

- **DRAWINGS**

- . All new drawings prepared by the Navy or the shipbuilder will be dimensioned in metric units.
- . Existing standard drawings and vendor furnished drawings need not be converted.
- Equipment designed in U.S. customary (inch-pound) units will be shown on arrangement drawings with soft metric dimensions.

- . **ENGINEERING CALCULATIONS**

- . Metric units preferred, but not required.

- **MIL-SPECS & MIL-STDS**

- NavSea is in the process of converting, but resources are limited and pace is slow.

New designs will utilize metric practice to the extent that performance requirements are met and no significant cost, schedule, or technical risk is involved.

In general, NavSea's metric planning for the LX and future surface ship designs is based upon two broad objectives:

1. New designs will utilize metric practice to the extent that performance requirements are met and no significant cost, schedule, or technical risk is involved.
2. There is no intent to drive the vendor base by requiring redesign to metric dimensions.

drive the vendor base by requiring redesign to metric dimensions.

There is a large gray area in NavSea's planning assumption 1 above, ". ..to the extent that performance requirements are met and no significant, cost, schedule, or technical risk is involved." If these words are invoked upon a contract without further clarification or parameters for determining "significant... risk", it will likely open up a new forum of discussion between shipbuilder and customer reminiscent of those surrounding "good shipbuilding practice".

Foreign Military Sales vessel construction will undoubtedly be pursued more aggressively, especially by those shipyards caught in the downsizing of the Navy's shipbuilding program. It's almost certain that the specifications for these ships will require some degree of metric design, if not hard metric materials and components due to their foreign origination.

Noncombatant Navy and other government agency shipbuilding, generally consisting of patrol and support vessels of less than 1000 gt has averaged around \$300 million over recent years and is projected to maintain this level over the next several years. Being that these vessels will be contracted under federal metrication guidelines, it is almost certain that they will carry with them metric specifications similar to those put out by NavSea, especially since NavSea will act as shipbuilding liaison for some of them.

3.3.2 Commercial - Oceangoing

Shipbuilding forecasts, in general, indicate that the demand for commercial ships will increase significantly in the 1990's. The primary reasons for this optimism are the aging merchant fleet, effects of the Oil Pollution Act of 1990, and projected expansion of the world fleet, assuming the economy cooperates.

The petroleum tanker fleet comprises the bulk of the world fleet in gross tonnage. As OPA-90 regulations come on line beginning in 1995, it is estimated that 40-50 tankers³ will be forced out of operation between 1995 and 1998. This, combined with the aging of the fleet will finally begin to turn the excesses of the 80's into opportunities for U.S. shipbuilders. Newbuildings in the rest of the world fleet (containerships, RO-RO'S, cruise ships, etc.) are projected to see a modest increase in the 90's overall.

What this means to U.S. shipbuilders in terms of metrication depends mainly upon the prospective customer and the ship's intended operating waters. Being that the vast majority of the world fleet (excluding Jones Act vessels) has been constructed in foreign countries to metric specifications, it is only logical to assume that additions to

Being that the vast majority of the world fleet (excluding Jones Act vessels) has been constructed in foreign countries to metric specifications, it is only logical to assume that additions to or replacements for the fleet also will be to metric spec's.

or replacements for the fleet also will be to metric specifications. Jones Act ships are another case, having been constructed in U.S. shipyards and operated in U.S. ports and waters to inch-pound specifications.

Queries were sent to ten ship operators, requesting input to this project, to which none responded. This can be interpreted to indicate either their lack of interest in the issue or the fact that U.S. shipbuilders have not been active enough in the commercial market to get their attention. In any case, the market value of metrication seems to be a non-issue for non-Jones Act vessels - the metric system is simply the standard by which the international fleet is built. For Jones Act ships, the market value of metrication will depend very much upon the individual customer's desires and outlook for the future of his fleet.

3.3.3 Commercial - Inland/Coastal

The outlook for Commercial - Inland/Coastal vessels (generally less than 1000 gt) is mixed, but generally uptrend. Healthy markets in casino boats, dinner/excursion boats, towboats, patrol craft, ferries, research vessels, fireboats, and petroleum barges are providing some relief for second-tier shipyards looking to replace dwindling Navy projects. Coastal tankers and product carriers are beginning to see a resurgence of shipbuilding interest, but actual contracts will be slow to come until OPA rules are promulgated and economic conditions stabilize. Fishing fleets are still trying to shake off excess capacity due to reduced stocks and quotas and a general overbuilding. The Great Lakes fleet of ore carriers will not likely see any additions until the end of the decade.

For the most part, the metrication influences of the U.S. government will have little direct effect upon this market sector. The major influence will likely be a secondary effect as the industrial supply base gears up to meet the metric demands of its government customers...

For the most part, the metrication influences of the U.S. government will have little direct effect upon this market sector. The major influence will likely be a secondary effect as the industrial supply base gears up to meet the metric demands of its government customers in other industries and makes metric materials more available and acceptable to the inland/coastal shipbuilder and fleet owner.

Even though foreign customer demand will play a much less significant role than in the bluewater commercial trade, it will still have an influence upon the metrication of the inland/coastal trade, mainly in the case of vessels for export. A case in point is a Pacific Northwest shipbuilder of primarily fishing vessels which exports much of their output and licenses their designs for foreign manufacture. Almost all of their design work and much of their procurement is done in metric units, although their default measurement standard for the yard is still inch-pound.

Discussions with the American Waterway Operators, which is generally representative of this sector indicate that there is little if any concern about the issues of metrication, leading to the belief that it will have little positive market value.

3.3.4 Repair/Conversion

Navy repair, maintenance, and conversion activity will continue to dominate this segment of the industry for the near future. Obviously, as the Navy fleet is downsized, repair/maintenance opportunities will be diminished. Counterbalancing this somewhat is the Ready Reserve Fleet's projected build-up to 140 vessels⁴, which will require, by MARAD estimates, an average of \$1 million per vessel per year in maintenance. With the closing of several government yards, the remaining private yards will have a better chance at contracting this work.

U.S. shipyards are competing aggressively in the domestic and foreign markets for commercial ship repair and conversion work as a replacement for new Naval construction. The demand for some ship repair services reportedly exceeds what is currently available in certain areas and is likely to do so in for the foreseeable future.

The market implications of metrication in the repair and conversion segment are more simplistic than in new construction. Repairs tend to be of an emergent nature, with relatively little pre-engineering and planning involved, making the choice of measurement systems almost a moot point. In all but the most critical applications, metric plate, shapes, and fasteners are interchangeable and compatible

Repairs tend to be of an emergent nature, with little pre-engineering and planning involved, making the choice of measurement systems almost a moot point.

with inch-pound equivalents with little problem. ABS, which has a policy of developing all new rules in hard metric dimensions does not discriminate against inch-pound unit based materials in repairs on metric ships as long as structural integrity is maintained. The replacement of metric components (pumps, filters, controllers, valves, etc.) may require some interface engineering to install inch-pound equivalents, but this may well be preferable to an extra day or two of lay-up waiting for the metric components to be shipped in if they are not available locally. In the case of conversions, overhauls, and other pre-engineered maintenance, the tendency will be to match the measurement system of the work to that to which the vessel was originally constructed as is generally the case at present.

If there is a competitive opportunity here for shipbuilders, it is most certainly in the preparation for these metric contracts to ensure that their bidding is based upon forethought, pragmatism, and hard data rather than conjecture.

3.3.5 Market Overview

The U.S. Navy and other government customers will be major drivers in the industry's move toward the metric system in the very near and long term future. It is more than likely that any new projects will be specified in some degree of metric terms, although at this time the degree of metrication economically feasible is an open question. The Navy's greatest concern is that the metric requirements do not drive the cost of construction prohibitively high, due to shipbuilders bidding in a "metric contingency factor" to cover the anticipated disruption and possible hidden costs (either real or perceived) in transitioning to the metric system. If there is a competitive opportunity here for shipbuilders, it is most certainly in the preparation for these metric contracts to ensure that their bidding is based upon forethought, pragmatism, and hard data rather than conjecture.

While the metric system's inherent simplicity and worldwide acceptance tends to enhance the marketability of a ship construction or repair job, the issue does not come into play until the overriding issues of cost and schedule are resolved to the customer's satisfaction.

Near term, the commercial shipbuilding/repair market for U.S. shipbuilders will be substantially unaffected by the current influences toward metrication. While the metric system's inherent simplicity and worldwide acceptance tends to enhance the marketability of a ship construction or repair job, the issue does not come into play until the overriding issues of cost and schedule are resolved to the customer's satisfaction. The offering of metric construction probably has its greatest marketing value in bluewater

commercial construction tankers, cruise ships, container ships), but again, until the U.S. becomes cost and schedule competitive in these markets, measurement standards will be a secondary issue, but one that will surely need to be resolved before a shipbuilding project goes to contract.

Jones act and other commercial inland/coastal work will feel a secondary effect from the government's metrication initiatives as the supply base accelerates its transition over the next five to ten years. Other than that, there are not a lot of motivating factors for metrication in this sector, although we are seeing some of the second tier shipyards actively promoting an industry move to metrication, simply for the sake of its simplicity and the desire to get on with the inevitable.

On a purely speculative note, an industry-wide initiative to adopt the metric system could have some market value on a macro scale, in that it could be a means to announce the industry's intention to aggressively rejoin the world market. One of the NSRP's long term goals is to regain 3% of the world market in shipbuilding (up from the current .2%). A unified and bold announcement of the industry's metrication plan will not likely sell any ships by itself, but could provide tangible evidence of the industry's seriousness of intentions.

A unified and bold announcement of the industry's metrication plan will not likely sell any ships by itself, but could provide tangible evidence of the industry's seriousness of intentions.

4.0 PRIORITY ISSUES

4.1 SUPPLY AVAILABILITY

Responses to the shipbuilder surveys (Appendix F) and interviews leading up to this report cited metric supply availability as the second greatest influence (right after market demand) affecting a company's decisions regarding metrication. And not surprisingly, procurement of metric supplies was cited as the most negative experience of a composite of those shipbuilders which had dealt with metric construction or repair/conversion.

As the basis for this project's survey of suppliers, a 1981 survey⁵ by Lockheed Shipbuilding served as a model. The Lockheed survey was performed as part of a feasibility study into the implementation of hybrid metrics in the then proposed DDG program. This project's 1993 survey was based very closely on the Lockheed survey and sent to the original respondents wherever possible (some were no longer in business and/or unlocatable) in order to derive comparative data. In addition, queries were sent to other suppliers of general manufacturing and shipbuilding materials. Of these, only 21 formal responses were received. However, follow-up phone queries provided sufficient information to form a general assessment of the metric supply base. The low response rate may be interpreted several ways: lack of recognition of shipbuilding as a significant part of their business, flawed survey questions, metrication backlash, etc. - all subject to conjecture. Whatever the reason(s), the situation is best summed up by an Ingalls report on the same subject⁶, "In the United States, the maritime industry is an essential industry, but it is not a major industry... It follows that the maritime industry cannot direct -- and perhaps cannot even strongly influence the metrication of its suppliers and of other industries with which it must work."

"In the United States, the maritime industry is an essential industry, but it is not a major industry... It follows that the maritime industry cannot direct -- and perhaps cannot even strongly influence the metrication of its suppliers and of other industries with which it must work."
from Ingalls Shipbuilding Metrics Study, 1982

The following is an overview of the basic groups of shipbuilding materials and their metric availability based upon current published data and information furnished by suppliers.

4.1.1 Structural Steel Plate and Shapes

The steel industry's response to metrication since the 1970's has been customer-driven. Being the universal construction material that it is, the industry has had to accommodate an array of applications and customers. The steel industry's multi-billion dollar modernization over the past decade has been designed in consideration of the growing metric market. Plate and sheet products can be rolled to any dimension without a cost or delivery penalty on mill orders. Shapes will continue to be rolled to their AISC standard dimensions (designations are nominal, with actual dimensions being neither rational inch-pound or metric units) and soft converted.

As long as orders can be placed in mill run quantities, pricing and delivery tends to be on a par with English unit based product, ...

Order quantities are a major factor in steel pricing. As long as orders can be placed in mill run quantities, pricing and delivery tends to be on a par with inch-pound unit based product, although not all mills are' capable of rolling metric sizes. Smaller quantities of plate and almost all metric flat bar, coming out of supply houses have been quoted at premiums of 5-20% over inch-pound for metric sizing.

4.1.2 Fasteners

Fasteners are readily available in hard metric configuration for most of the commonly used materials and configurations at competitive price and delivery. This is understandable as upwards of 80 percent of the industrial fasteners used in the U.S. are imported. However, inventories of less common materials (400 series stainless, silicon bronze) and configurations are still waiting for sufficient demand to drive supply. It is here that price and delivery will become factors since these "exotics" will be special order factory runs or manufactured offshore.

4.1.3 Propulsion, Steering Machinery

The supply base, especially for larger vessels, greater than 10,000 dwt is mostly imported or licensed for U.S. manufacture by foreign manufacturers and, for the

most part are already in hard metric configuration. This includes low and some medium speed Diesel engines, reduction gears, steering engines, and bow thrusters. Shafting and bearings are generally available domestically in either inch-pound or hard metric configuration with no cost or delivery penalty.

More machinery for smaller vessels tends to be produced domestically and thus, is less inclined to be of hard metric construction. However the trend is rapidly moving toward metrication as the suppliers seek international markets. The Navy's new boats and self-propelled service craft now entering the fleet are being powered by metric diesel engines manufactured in the U.S. by Cummins.

4.1.4 Mechanical Components

Many of the domestically produced mechanical components (pumps, ventilation fans, filters, air compressors, purifiers, etc.) intended for shipboard use over the past decade have been driven by Navy and DoD standards, which are almost exclusively in inch-pound measure. As federal procurements and standards are converted to metric units and per DoD policy, more commercial standards are specified, suppliers of these items will gear up to meet the demand for metric products. The conversion will, however be a lengthy process as long as defense budgets are pinched. In the meantime, there are suppliers of mechanical components, especially those with export markets capable of hard metric production and price and delivery terms competitive with inch-pound measurement counterparts. However, premiums of 40-50% have been cited by some survey respondents for delivery of metric units. Selective procurement is advised.

4.1.5 Pipe and Piping Components

This area will likely be the slowest to convert to hard metric production since there seems to be very little economic motivation for the use of metric pipe and components in the U.S. Compounding the problem is the lack of an international pipe standard system accepted and

This area will likely be the slowest to convert to hard metric production since there seems to be very little economic motivation for the use of metric pipe and components in the U.S.

followed by the major industrial nations of the world. A variety of pipe systems, all of which are metric, prevail.

Inquiries to several pipe suppliers, including one which was listed as a metric supplier in a metric vendor listing revealed that none had ever had any call for metric pipe, nor could they easily obtain it. Even the Construction Subcommittee of the Interagency Council on Metric Policy, which sets metrication policy for the federal government's construction does not require the use of hard metric pipe in its generally prometric guidelines. The LX program likewise does not require hard metric pipe and components.

For construction and repair of ships where metric pipe is specified, the lack of availability of metric pipe could be a problem unless a waiver is granted or, as a last resort the pipe is brought in from a foreign manufacturer. Metric hoses and fittings, on the other hand are readily available from several manufacturers.

Electrical parameters (voltage, resistance, current, power, inductance, etc.) have traditionally been considered in metric units...

4.1.6 Electrical Cable and Components

Electrical parameters (voltage, resistance, current, power, inductance, etc.) have traditionally been measured in metric units so there should be little, if any change to the functional characteristics of instruments and other electrical components, although their physical characteristics (mounting dimensions, interface connections) may still be in inch-pound dimensions on domestic products. This should not present much of a problem unless there is a requirement for hard metric components, but these are also relatively available.

Domestic production of metric cable is usually on a special order basis, with the inherent price and delivery considerations. The use of metric cable is not likely to be widespread or quick in coming, the American Wire Gage (AWG) being commonly acceptable in much of the metric world. There is probably more AWG wire exported than metric is imported and the situation is not likely to change with government procurements. Both the federal construction guidelines and the LX program call only for the soft conversion of conventional cable as part of their metrication policy. Equivalencies are easily arrived at

between AWG and metric cables and the most prudent response to a requirement for metric cable is to request a waiver if the metric product is noncompetitive in price and/or delivery.

Electrical components (switchgear, transformers, terminal boards, enclosures, stuffing boxes) are perhaps more readily available than cable in hard metric configuration, but again, due to their limited sales volume in the U. S., they will generally cost more.

4.1.7 Deck Machinery

Availability in hard metric configuration is largely a function of the equipment's origin. Again, many of these items produced domestically are the products of long-standing government standards in inch-pound measurement. It will take a long time to convert them to metric units and many may very well be obsolete by the time they get converted. In the meantime, the increasing use of commercial standards by the DoD and a relatively strong foreign supply base will tend to make metric configurations increasingly available.

4.2 WORKFORCE TRAINING

The Canadian shipbuilder, St John's Shipbuilding is in the process of building twelve Canadian Patrol Frigates under a \$6 billion contract. They report that no special training was provided to Engineers, Draftsmen, Purchasing staff, or shipyard workforce, with no adverse effects upon the contract's performance. However, they also qualify this statement with the fact that Canada, as a nation was well into metrication, with most consumer products and measurements being in metric, which provided a subtle, but highly effective form of training which is not yet available in the U.S. Also, it should be noted that Canadian education including trade apprenticeship programs are conducted in the metric system.

St. John Shipbuilding ... reports that no special training was provided to Engineers, Draftsmen, Purchasing staff, or shipyard workforce, with no adverse effects upon the contract's performance.

Lacking this metric background for the workforce, U.S. shipbuilders are faced with providing it on the job. Respondents to the shipbuilder survey were asked, "In

... "In developing a metrication strategy for the shipbuilding industry, what do you feel is the most important issue to address?". As a group, shipbuilders ranked training as the highest priority.

Top level management must provide a firm commitment to metric.

developing a metrication strategy for the shipbuilding industry, what do you feel is the most important issue to address?". As a group, shipbuilders ranked training as the highest priority. While this was a high priority in other U.S. industries and companies which have converted, their experiences have shown that training need not be highly formalized or expensive.

4.2.1 Training Guidelines

The American National Metric Council and the U.S. Metric Association recommend the following management and training measures:

- Top level commitment. Top level management must provide a firm commitment to metric. This includes:
 - Announcing a formal policy,
 - Forming a metric committee, and
 - Appointing a metric coordinator to chair the committee and act as the organization's metric representative.
- Metrication schedule. Develop an organization-wide medication schedule with milestones and a completion date.
- Metric organizations. Consider joining the American National Metric Council and/or the U.S. Metric Association.
- Metric publication. Begin a metric reference library (See Appendix 1).
- Training objectives. Write carefully worded, measurable training objectives with the goal of, "enabling employees to perform their jobs with the same or greater degree of efficiency using metric".
- Define the learner population. Determine who needs to know metric and to what extent they need to know it. Some employees may require an in-depth working knowledge of metric, whereas others may never need to know it at all. Most probably will need to know only a few metric units.
- Determine training needs. There are three levels of training:
 - Metric awareness training to help all employees overcome fear and resistance to change,
 - Management training to educate the people responsible for the transition to metric, and

•Implementation training to teach specific metric skills to specific employees.

- Training should take place just Prior to when an employee will use the new knowledge on the job; earlier training is ineffective.
- Train only as needed. Train only as necessary to meet the goal of "enabling employees to perform their jobs with the same or greater degree of efficiency using metric". Training is not a panacea, and massive training programs are wasteful. Often, training can be performed completely on-the job.
- Train people to think metric. Link metric measurements to familiar objects. Avoid comparisons to inch-pounds as much as possible.
- Monitor the metrication program. Make sure training matches the organization's metric transition schedule. If something changes, adjust either the training or the schedule.
- Don't hide costs. There is a cost to metric conversion, both in time and money. Plan for it in advance, and monitor costs as transition takes place.

Shipbuilding is highly measurement-sensitive and these measurements have a wide-ranging affect on all operations in the shipyard. Material specifiers must be knowledgeable of the contract's requirements and the shipyard's policy in specifying either inch-pound or metric supplies. Engineers, designers, and draftsmen must be able to not only convert back and forth between metric and inch-pound measurement, but to visualize in metric terms. And certainly the production worker must be able to interpret the language of metrics and convey it into a finished product. A well rounded training program should consist of three mutually-suppom"ve elements as described in the following sections.

4.2.2 Metric Theory and Conversion {MT&C}

This is the typical classroom instruction with a course outline consisting of the background and basic tenets of the metric system. It's purpose is to teach the use of conversion factors and charts, rules of thumb, and various metric measuring devices. This is basically a refresher course for the scattering of metric instruction that most

A primary function of this training should also be to explain the rationale behind the conversion and solicit the trainees' participation as part of the solution to a corporate challenge.

public schools' provide. Course outlines and instructional materials are available from several sources (Appendix I) for in-house instruction by company personnel or metric training specialists can be called in to do the training.

A primary function of this training should also be to explain the rationale behind the conversion and solicit the trainees' participation as part of the solution to a corporate challenge. It has to assumed that a certain percentage of the workforce will harbor an innate resistance to a change from the traditional system and a thorough explanation of the reasoning behind the change will go a long way toward softening the resistance or at least open them up to training.

Peterson Builders, as part of this project developed a training package (Appendix H) along these lines to prepare employees from production, engineering and support trades for work on a Navy metric contract for the construction of 13 meter patrol craft. The training consisted of three 3 hour sessions presented to 14-15 person groups. A local technical college was retained to provide the classroom and do the actual instruction. Feedback from the trainees indicated that the basics of the metric system could have been covered adequately in much less time, whereas more attention was needed (not necessarily in the classroom) on the implications of the conversion on their specific jobs.

4.2.3 Metric Application Training

Metric Application Training can be much less structured than MT&C and consists primarily of the development of a thorough understanding of the application of the metric system to the trainees' specific jobs. This may include drawing preparation and reading, equipment calibration, metric material specification and identification, etc. In many cases this training needs to amount to no more than a brief session to review a contract specification and company policy concerning metric usage. In other cases this may require a more extensive and formalized sessions, but in all cases the training should remain cost-effective by limiting itself to those metric issues which directly affect the trainee's performance on a particular contract. This training, as well as MT&C should be

Aside from a classroom setting, if a company has a TQM, Quality Circles, or similar employee involvement program, this would be an ideal environment for discussion of metrication topics.

conducted for only those workers (and management) who will be directly involved in upcoming metric work.

Aside from a classroom setting, if a company has a TQM, Quality Circles, or similar employee involvement program, this is an ideal environment for discussion of metrication topics.

4.2.4 Metric Indoctrination

This is simply the reprogramming of our minds to think and visualize metric measurements without doing mental conversions to the equivalent inch-pound unit measurements. This is not to say that we must, or even want to abandon thinking and visualizing in inch-pound units. Even with a revolutionary change to the metric system in this country, we will still be seeing and using the inch-pound system for a long time. What we need to do is be comfortable with both systems during the transition, because until we do, we will always be thinking of one in terms of the other. This unnecessary mental exercise leads to confusion and potentially costly rework.

The agenda for this element of the program is not easily defined since it is a much more subtle form of education than the other elements. It simply involves a consistent but low key program of metric reminders placed unobtrusively in front of the workforce. It's analogous to a safety campaign, where posters, newsletter items, and other relatively innocuous tactics are used to encourage employees to think safety, except in this case they're encouraged to think metric. There are numerous sources for metric informational and motivational materials (Appendix I) which include posters, handouts, videos, and other aids, which serve to reinforce the concepts of metric measurement in a very non-threatening manner, while conveying to the workforce management's commitment to a metrics policy.

It's analogous to a safety campaign, where posters, newsletter items, and other relatively innocuous tactics are used to encourage employees to think safety, except in this case they're encouraged to think metric.

4.3 FACILITIES AND EQUIPMENT

Tools, equipment, and facilities will, in most cases not require major revamping or replacement. Machine tools calibrated in inch-pound units can usually be set up simply

Tools, equipment, and facilities will, in most cases not require major revamping or replacement.

by using proper conversion factors, performed either by the machine setup person or by engineering as part of the drawing package. The machining of metric screw threads and tapers requires the machine to have a physical capability to coordinate its movements in metric units. Numerically Controlled (NC) machines are controlled in sufficiently fine machine units to produce surface geometries within inch-pound or metric tolerances. However, unless the machine has direct metric capabilities the dimensions must first be converted to inch-pound units for programming. In the case of manually controlled machine tools, the cutting of metric tapers and threads usually requires the replacement of gearing. However, most minimally equipped machine shops will have the gearing already on hand. Machine tooling that will most likely require purchase or additional purchase are drill bits, taps, dies, reams, dimensioned contour cutting tools, and other nonadjustable, hard dimensioned expendable items.

Some inch-pound tooling may be compliant with metric construction and their replacement with metric equivalents should be considered only as the tool requires replacement due to normal wearout. As an example, a wood router bit with a 1/2" radius is suitable for cutting a 12 mm radius wherever the slight difference is not critical for fit or appearance. On the other hand, many companies have justified the immediate replacement of their inch-pound drill bit sets with metric bits by the elimination of a confusing array of fractional, letter, wire gauge, and decimal sizes in favor of one set of metric sizes. Caterpillar drills metric holes even for the remaining inch-pound fasteners it uses.

5.0 COSTS vs. BENEFITS OF METRICATION

5.1 BENEFITS

The potential benefits of metrication are a nebulous lot. Improved access to world markets, compliance with government procurement mandates, expanded supplier base, simplified design and construction measurements are all noble pursuits, but very difficult, if not impossible to quantify in dollars, especially as a generalization for an industry. Shipyards must individually calculate through subjective analysis the potential benefits they stand to gain as a result of metrication. A yard planning to concentrate on government and/or foreign work will no doubt see more value from a marketing standpoint than one which is working in the inland commercial market. At the same time, the inland/commercial yard may take a more proactive approach, based upon exploiting the metric system's simplicity. It is only upon assessing the potential value of metrication to an individual shipyard that a metrication policy can be decided upon. Once the need and extent of metrication have been identified, a specific action plan can be developed upon which costs can be based. Table 1 presents a balanced view of the arguments for and against metrication, all of which should be considered in doing a cost-benefit analysis.

Improved access to world markets, compliance with government procurement mandates, expanded supplier base, simplified design and construction measurements are all noble pursuits, but very difficult, if not impossible to quantify in dollars, especially as a generalization for an industry.

It should be noted that the potential benefits of metrication are not limited to a simplified system of measurement units or expanded market capabilities. If taken as *part of* a long term corporate strategy, metrication can serve as a facilitator for other needed changes. It's an opportunity to rethink those operations affected by metrication and introduce upgrades where necessary. Examples:

- Reduction of inventory. Almost all companies have inactive inventory or materials listed in their stock list that are obsolete or duplicates of others. As metric materials are introduced into the system, similar items should be reviewed for their currency and a limited number standardized upon. Fasteners are a common beneficiary of metric standardization (See Section 6.1.1), but any material used in shipbuilding is a candidate for standardization.

<u>ADVANTAGES</u>	<u>DISADVANTAGES</u>
• Foreign customers are more accepting of metric design and construction.	• Domestic customers may be less accepting of metric design and construction.
• Enables shipbuilder to be more responsive to U.S. government customers who are obligated to metrics.	• Pace of Government metrication may not be in sync with industry needs and capabilities.
• Improved efficiency can be realized in design, mfg, and support trades.	• shipyard will incur initial costs for training and retooling.
• Expands supplier base to the entire world: -more competitive pricing -best available technology	• Domestic suppliers are not fully geared up to supply metric products at competitive terms. May conflict with Buy American Act.
• Enhances capabilities of shipbuilders and allied industries to team with foreign partners.	• Requires dual capabilities (inch-pound and metric) during transition period.
• Opportunity to rationalize inventories of stock materials.	• Dual inventories of stock materials will be necessary during transition. Maintenance of existing ships complicated.
• Opportunity to rationalize and upgrade existing standards (company and industry) to reflect current requirements and technology.	• Standards that were written in inch-pound units need to be converted or replaced with metric equivalents.
• Simplifies acceptance by foreign classifiers and regulators.	• As transition continues in this country, some confusion may ensue.
• Calculations are faster, less prone to errors due to base ten numbering and measurement system.	• Formulas and raw data for calculations may have to be converted from inch-pound units.
• Base ten measurement system is inherently more efficient and less error-prone on the shop floor.	• Requires retraining, recalibrations, and some retooling.

TABLE 1

- Development or upgrade of design standards. The value of design standards is well established, but often find themselves not current or nonexistent within a shipyard. As metric design is being introduced, there is an opportunity to develop or upgrade design standards.
- implementation of improved technologies and processes. Technologies such as Accuracy Control and Zone Outfitting are measurement intensive, requiring new and modified procedures in their implementation. The introduction of the metric system concurrent supports these technologies with a simplified measurement system.

5.2 COSTS

If there is one rule to follow here, it is, "Don't overestimate the problem. " Metrication tends to carry some emotional baggage with it which causes management to overreact to its ramifications. General Motors, which is now fully metric after a decade-long transition has expended less than 1 percent of its original estimates for conversion costs. The key to minimizing costs is planning based upon projected benefits and hard cost data.

"Don't overestimate the problem".

The following costing model is based upon the design and construction of a metric ship with requirements similar to the Navy LX program (Section 3.3.1). Costs are broken down into three general categories: Administration, Training, and Facilities. For the purposes of rationalizing costs they are further broken down into estimated costs per affected direct labor charging employee, since it is likely that other nonmetric contracts will be coexisting in the shipyard and this will allow the model to track costs directly to a metric contract.

Several assumptions were made in the development of this model:

1. No allowance has been made for any increase in the cost of shipbuilding materials and components due to their metric configuration. This is such a variable from ship to ship that it is virtually incalculable. For instance, the steel prices for a metric LX or similarly sized ship will not be affected as long as mill runs are ordered. However, for smaller projects requiring smaller quantities

As long as economics play a part in shipbuilding, any material price differential brought on by a metric requirement should be positive, minimized, or justified by an offsetting benefit or savings.

No allowances have been made for either the short term disruption or the long term efficiency gains of metrication....For the purposes of this costing model, they are acknowledged to exist as offsetting each other - Net effect = zero.

of steel from supply houses, the price differential could be significant. As long as economics play a part in shipbuilding, any material price differential brought on by a metric requirement should be positive, minimized, or justified by an offsetting benefit or savings.

Pricing of metric materials as a factor in the overall cost of a metric ship is very much dependent upon the contract's and material specifier's definition of a "metric" ship (See Section 6.1. 1.3). If the definition of "metric" is limited to those items of metric material that are reasonably available at competitive pricing, then material pricing should be little if any factor in the final cost of the ship. If however, the metric ship is defined as metric at any cost, requiring procurement of materials based mainly upon their metric characteristics rather than their functionality and economics, then material pricing will be a significant factor. This model is based upon the former definition.

2. This model does not include the conversion of existing company design standards which should be factored in either as a direct charge to a contract or as indirect labor (Section 6.1.1.1). It is not included here since this is highly variable from company to company. Nevertheless, a factor should be included in the final calculation to account for any expense.
3. No allowances have been made for either the short term disruption or the long term efficiency gains of metrication. This is not to ignore their potential, but all the data available concerning these opposing factors are anecdotal in nature and do not lend themselves to calculation. For the purposes of this costing model, they are acknowledged to exist as offsetting each other - Net effect = zero.

5.2.1 ADMINISTRATIVE COSTS

These are the costs associated with setting and implementing metrication policy. It includes the time of management, the metric coordinator, and clerical staff which is normally charged to indirect labor. Assuming 10% of management's time will be spent on setting and implementing metric policy for one month with steadily diminishing demands' over the next year, a median of 5% is used in the model. (These figures will, of course vary from

shipyard to shipyard depending upon the extent of metrication and the efficiency of transition. They were chosen as a reasonable estimate for illustration purposes in this model .) At a ten to one ratio of direct labor chargers to indirect chargers, this calculates as follows:

<u>Admin (indirect) charges = 1 ind. empl x 5% x 2080 hrs = 10.4 hrs</u>			
Direct charge employee	10 dir empl	year *	DC empl
*Assumes a one year, nonrecurring transition period			

5.2.2 TRAINING COSTS

Based upon this project's training outline (Appendix H), 9 hours per affected direct charge employee is allocated.

5.2.3 FACILITIES COSTS

This includes those additions and enhancements required immediately to perform a metric ship design and construction. It consists of hand tools, recalibration of machine tools, dual warehousing (if necessary), reprogramming of computer software, training materials, and procurement of shop and test equipment where necessary. The figure of \$300 per affected direct charge employee used here is, admittedly an arbitrary one, used for illustrative purposes in this example. Actual values will be based upon calculated needs per individual shipyard.

5.2.4 COST CALCULATION

Using the values obtained from the previous sections and applying an average fully burdened labor rate of \$30 dollars per hour:

ADMINIST.	10.4 hrs x \$30 = \$312/DC employee
TRANINING	9.0 hrs x \$30 = \$270/ " "
FACILITIES	= \$300/ " "
TOTAL	= \$882/DC* employee

I * - Direct Charge

Assuming that a project of this manning requirement will have contract value of at least \$40 million, this expenditure works out to be 1 - 1½% (non-recurring) of the contract value.

Based upon a hypothetical project which requires 500 direct charge employees, this example suggests an increase in the shipyard's costs by about \$440,000 due to implementation of metrication. Assuming that a project of this manning requirement will have contract value of at least \$40 million, this expenditure works out to be 1 - 1½ % of the contract value. It should be kept in mind also that these are lead ship, nonrecurring expenses and any subsequent metric ships, whether of the same design or not, will benefit from this effort without additional expense. The only other subsequent expenses would be the training of additional personnel as they are brought into metric work, but again, this is a one time expense per employee. Improvements in productivity, wider supplier base, more rational stocks of components and materials, and other benefits will continue to be realized on subsequent hulls and other contracts.

These findings depart from previous reports asserting that ship acquisition costs would become prohibitively high in metric configuration.

These figures generally coincide with the responses to the shipbuilder survey (Appendix F) which as a group was about evenly split between the opinions that metrication would not substantially affect a bid price. or would increase it. One yard consistently stated that it would result in a lower bid price. Survey respondents were not asked to quantify any increases or decreases.

These findings depart from previous reports asserting that ship acquisition costs would become prohibitively high in metric configuration. MARAD has stated that they have "identified a 20% increase in cost for the initial ship designs in the metric system. " due to increased manhours for familiarizing designers with metric usage and searching out metric supplies. NavSea predicted a 12.6% cost increase on the LX program due to its metric requirements. in requesting a waiver from the metric requirements, NavSea cited an estimated increased cost of \$109.13M for metrication of the lead ship of the DDG 51 class. The PHM was also cited as having a 260% budget overrun, \$40M of it due to "metric retooling. "

Several factors contribute to the discrepancy between the cost projection in this report and those of previous reports. First and foremost is the sense that the analyses that the NavSea projections were based upon took

a "metric at any cost" approach in its procurement philosophy rather than a "metric, if you can do it reasonably" approach as espoused in this report. Massive retooling and protracted searches for metric materials and components may result in a highly metricized ship, but not necessarily an economically sound project. Second, there is an overriding assumption that the transition to the metric system will result in inordinate delays, disruption and rework in design and construction. This assertion is not borne out by the information gathered by this project, both from those companies outside the industry and from those shipbuilders who have had metric experience and provided adequate training. There seems to be a contingency factor thrown in to cover the unknown. This study supports the view that these factors are based upon conjecture and are neither calculable nor able to be substantiated by historical data. Third, the shipbuilding projects used in the argument for high metrication costs were contracted on a cost plus basis. In the current days of firm-fixed pricing and stiff competition for a limited shipbuilding budget, everyone, shipbuilder and Navy are more likely to sharpen their pencils.

Massive retooling and protracted searches for metric materials and components may result in a highly metricized ship, but not necessarily an economically sound project.

6.0 SETTING METRIC POLICY

6.1 COMPANY POLICY

Top level management must, above all educate itself on the issues of metrication and their affect upon their company before it can reasonably set policy on them. Issues, such as inch-pound/metric material selection can have a tremendous effect upon a contract's profitability and require nothing less than top level attention and guidance to ensure that they are handled in an economically sound and consistent manner. Caterpillar, which has had a metrication program in place since the early 70's, starting with the use of metric dimensions on drawings, is still in the process of converting all its fasteners over to metric. Caterpillar's move from inch-pound to metric fasteners was planned and implemented as a high level policy, taking into account such considerations as long term supply contracts and emerging foreign manufacturing affiliations. The workers who must make the necessary day to day decisions on metrication do not typically have access to this sort of information nor would they be able to assimilate it consistently without top level direction.

One of the first considerations in setting a metrication policy is the company's target market. A shipbuilder anticipating a majority of work in Navy and other U.S. government work will certainly be more inclined to adopt a more aggressive metrication policy than one which will be working primarily in the commercial inland market. Regardless of markets, any shipbuilder must expect that they will be affected by the long term trend toward metrication, and even those that do not see themselves in a high impact market now will find themselves dealing with the secondary affects of those markets (transitory supply base, regulatory changes, subcontracts) over the next several years.

What must come out of this process is a policy that the entire company will be comfortable with and one which is based upon sound economic principles. Like any other policy, it requires a mechanism that allows for timely feedback and the flexibility to adapt to changing conditions.

"We have taken a positive approach to the metric system and we urge other companies to do so."

*Robert Slass, President
Rotor Clip Company*

Regardless of markets, any shipbuilder must expect that they will be affected by the long term trend toward metrication, and even those that do not see themselves in a high impact market now will find themselves dealing with the secondary affects of those markets over the next several years.

Above all, management must be prepared to back the policy up with the resources necessary to implement changes in procedures, equipment, and training.

While it is impossible to prescribe a universal metrication policy for U.S. shipyards, it is possible to generalize the experiences of other organizations into models of policy for a shipyard's various operational functions.

6.1.1 Engineering

This is usually the function that is first and most directly affected by any metric issue and it should be the first to be addressed in setting a metric policy. It is also the area that can most affect the success of a metrication program in other functions of the shipyard and is therefore deserving of critical attention.

The transition to metric engineering requires planning, training, and discipline, but it does not need to be disruptive or costly. The shipbuilder respondents to the survey generally stated that their experiences in metrication have had little, if any effect upon their engineering functions. In fact, 25% had rated their engineering experience as somewhat or highly positive.

A British heavy engineering firm reported that its drawing production rate showed no change when metrics were first introduced, but upon familiarization, productivity increased by 15%.

The National Institute of Building Sciences reports⁸, "There was no appreciable increase in either design or construction costs, and conversion costs for most construction industry sectors were minimal or offset by later savings. Design firms found that it took a week or less to begin thinking in metric; most tradespeople adapted in only a few hours". A British heavy engineering firm (U.K. went metric in 1972) reported that its drawing production rate showed no change when metrics were first introduced, but upon familiarization, productivity increased by 150%.

Many companies have found that an orderly transition to metric engineering is an ideal opportunity to examine all aspects of their engineering operations and implement cost-saving concepts in parallel with metrics. Most often mentioned is the opportunity to rationalize the

material stock list, particularly in fasteners and structural shapes. Ford of Britain took this opportunity and reported a savings of 2,500,000 pounds (3,750,000 USD) per year in fasteners alone. Caterpillar reports, "As a result of the reduction in the number of sizes and the forced review of the selection of raw material sizes, a \$1,000,000 /year savings was realized. This, it is felt pays for the total cost of conversion.". Rationalization of fastener sizes at IBM during metric conversion reduced fastener part numbers from 38,000 to 4,000.

If there is any one characteristic that is common among those companies that have successfully managed a transition to metric engineering, it is that it was done not as a stand alone implementation, but as a ground up reassessment of their engineering operations, with metrication as the catalyst for the implementation of other previously needed changes.

The keys to a successful implementation of metric engineering practices are:

1. The establishment and dissemination of written guidelines to all engineering and non-engineering staff who will be involved in the development and interpretation of drawings, calculations, and material lists. Beyond these written guidelines, there will undoubtedly arise on a day to day basis, situations that require an interpretation or expansion of the guidelines. A metric engineering coordinator should be assigned to handle these situations in a timely and consistent manner, as well as monitoring the overall application of metrics. This is very important, especially on a first time metric contract and/or working with an outside design firm and other subcontractors who may not be familiar with metrics.
2. Sufficient training to ensure a thorough understanding of the basics of metrics as they apply to the engineering functions. If it can be said that training is more important in one area of the shipyard than the other, then engineering would have to be that area. Despite the metric system's inherent logic and simplicity, the transition from the inch-pound system may be a breeding ground for errors, confusion, delays, and general discontent if not handled at the outset with a

Rationalization of fastener sizes at IBM during metric conversion reduced fastener part numbers from 38,000 to 4,000.

Metrication and the hybrid nature of these frigates did not cause ANY problem during the design and that includes a large portion of the working drawings sub-contracted to an American company. St. John Shipbuilding, New Brunswick, Canada

training program that addresses metric usage and conversion on every aspect of every job.

"Not only is the metric system easier to use, but as has been experienced by the construction industry in engineering design, fewer errors are made when the metric system is used in place of the inch-pound system." *"Metrication: An Economic Wake-Up Call for U.S. Industry", Dr. Gary Carver, National Institute of Standards & Technology*

There are many issues involved in metric engineering which go beyond the scope of this report and, in most cases must be addressed at the individual company level. These include terminology, the use of metric symbols and prefixes, rules for conversion, and other items of recommended practice. Fortunately, there are numerous standards and published guidelines (Appendix I) which provide general guidance in all areas of metric drawing practice. Individual shipyards and design firms should develop their in-house metric drawing standards based upon these existing standards and publications, rather than attempting to develop them from scratch. Upon approval by management, they must be made visible and available to all personnel as part of the company's standards program.

For the purposes of this discussion, engineering is considered to consist of the sub-functions of drawing preparation, calculations, and material/parts specification.

6.1.1.1 Drawing Preparation

The overriding issue here is the decision to prepare the design in soft or hard metrics. In the case of Navy (See Section 3.3. 1) and U.S. government contracts, hard metrics (rounded integer metric units) will most likely be specified for all construction dimensions on new design classes, leaving little leeway for internal decision-making on this issue. Frame spacing, deck heights, hull lines, equipment locating dimensions will all be defined in hard metric units. Material and equipment specifications will continue to be a mix between metric and inch-pound unit measure. Nongovernment contracts will be subject to the customers' desires as to dimensional standards, with foreign originated specifications and designs tending almost exclusively to metric units.

With the wide-spread use of CAD, the issue of whether to prepare drawings in inch-pound or metric units is relatively inconsequential. On command, a drawing's dimensions can be converted from one measurement

system to the other in a matter of seconds with a high degree of precision. The temptation is to dual dimension drawings with both inch-pound and metric units, but it has been generally a regrettable decision by those companies that have gone this route due to the space required on complex drawings and the potential for transposing units from one set of numbers to the other. MIL STD 1476B, "Metric System Application in New Design" (Appendix J), which will likely be used with future Navy contracts prohibits the use of dual dimensioning and this policy should be extended as a rule to all other contracts with metric drawing specifications. The exception to this rule may be in those cases where nominal inch-pound units are used to designate a standard item of material or equipment, such as in the case of lumber (2x4's, 1 x6's, etc.).

One of the issues mentioned repeatedly in discussions with shipbuilders is the use of design standards, either company proprietary, government, or commercial/ industrial which were developed in inch-pound units, but must now be invoked upon metric drawings. Company standards represent a substantial investment and their conversion would involve more capital outlay, especially if a hard conversion is required. In the case of noncompany standards, especially DoD and NavSea, these will eventually be converted but not in the near future. There are several alternatives for addressing this problem, none of which, by themselves seem to be the universal solution. They include:

- Convert company standards as needed on a particular contract and charge or bid the immediate contract for the conversion expense. This seems to be a workable solution as long as the burden of conversion allotted to the one contract does not put the shipbuilder in a noncompetitive pricing situation or the customer balks at the direct charging of what could be considered indirect expenditures.
- Convert company standards as needed and charge expenditures as indirect. This will, of course assume that the company will enter into future metric contracts upon which to amortize the costs.
- Leave the standards in inch-pound units and allow the end users (procurement staff, production Wades, vendors, planners) to convert them as necessary. This is the most economical solution as far as engineering

Company standards represent a substantial investment and their conversion would involve more capital outlay, especially if a hard conversion is required.

"Metric (SI) units will be the only system used for expressing weights and measures. All boards and committees will fully convert to this system by December 31, 1992."
from Society of Automotive Engineers (SAE) Metric Policy for standards.

costs go, but is subject to even greater, but less tangible costs, depending upon the accuracy and consistency with which any conversions are performed (engineering has now lost some control over dimensional accuracy). This alternative must be agreed upon early on since some users may resist doing what they consider to be engineering work - with some justification.

- Encourage the use of equivalent metric standards as a substitute for inch-pound unit standards. There are thousands of standards available for use by the shipbuilding industry which are not being taken advantage of. Many of them are more technically current than those in common usage by U.S. shipbuilders. Nearly all of these are metric standards and the majority are internationally recognized. Those standards which meet the requirements of a contract's specifications and are in metric configuration should be identified and proposed as substitutes for their inch-pound unit equivalents. ASTM currently dual dimensions their standards and SAE, as of the end of 1992 develops all new standards in metric units.
- in the case of Navy contracts, enter into an arrangement with NavSea to convert contract-applicable NavSea and DoD standards under their cognizance into metric configuration as part of the contract's scope of work. The shipbuilder is compensated for the work and NavSea gets its highest priority standards converted in a timely and cost-effective manner. This approach would best be initiated at the industry level to ensure a coordinated effort with NavSea.

6.1.1.2 Calculations

Working in a base ten numbering system with a base ten measurement system is an ideal situation, especially if the basic formulas are already presented in the metric system. The scientific community has recognized this for many years, doing their work in the metric system almost exclusively. The logic and simplicity of calculations in metric units are immediately obvious to any engineer who has struggled with the archaic inch-pound system of units and calculations. For example, which has a higher thermal output, a 22 million Btu/hour boiler or a 1000 ton chiller? Using metric units, an engineer can tell instantly: the boiler

is 6.4 MW and the chiller is 3.5 MW. In many cases calculations are insensitive to the units of measurement used in them, the exception being where constants and ratios are used which are based upon a specific unit of measure. These are not interchangeable between inch-pound and metric units and must be identified clearly as either inch-pound or metric based formulas. Fortunately, there is a wide availability of metric formulas, software, conversion charts, and calculators (Appendix 1).

The transition to metric calculations can be a simple, painless, and even productive experience as long as a few basic guidelines are established and applied consistently. The most immediate question to come up is whether to convert the data going into the calculation to metric units from the beginning or perform the calculation in the originating units and convert only the final product to metric units. In most cases it is preferable to work in the units that the final answer will be presented in, but there are several exceptions to that rule. Wherever a high degree of precision is required, such as machining operations, it is preferable to convert only the final product in order to avoid cumulative conversion errors due to rounding. Also, some traditional shipbuilding measurements do not lend themselves to conversion to metric units and should not be forced just for the sake of it. For example, the knot will not likely give way to the preferred SI metric unit (per ASTM F1332-91, Standard Practice for Use of SI Units in Maritime Applications) of meter/second in the near future. Even though there is abundant published guidelines concerning these questions, their final resolution should be approved by the metric coordinator and documented as part of the company's metric policy (standard) to be carried forward to the next application.

...some traditional shipbuilding measurements do not lend themselves to conversion to metric units and should not be forced just for the sake of it. For example, the knot will not likely give way to the preferred SI metric unit of meter/second in the near future.

6.1.1.3 Material Specification

The specification of material on a metric design must take into account all of the traditional selection criteria, metric vs inch-pound configuration being an additional, but not necessarily overriding factor in the selection process. How this factor is weighted depends largely upon the contract's metric requirements and the customer's commitment to them. Policy and standards must be

Caterpillar, which began its metrication program in the early '70's is still in the process of transitioning to the full use of metric fasteners, simply because there was no economic or market value in accelerating the schedule.

established to ensure that this requirement is balanced with the other selection criteria, resulting in specifications for materials that are readily available, economical, functional, and comply with the customer's requirements.

In making metric procurement decisions, it should be acknowledged up front that metric products and materials are inherently no better or no worse than their inch-pound counterparts. They are not necessarily less or more expensive; their quality and serviceability vary just the same as do products built to inch-pound measurements. When it comes right down to the buying decision, a metric product will be bought for one of two reasons. The foremost and most economically viable reason is because it is the best product available at a reasonable price and delivery. The second reason is simply because that is what the customer specified. It is this second reasoning, blindly adhered to, that will drain profits from a contract very quickly. Caterpillar, which began its metrication program in the early '70's is still in the process of transitioning to the full use of metric fasteners, simply because there was no economic or market value in accelerating the schedule. Ingalls Shipbuilding, in conducting a metric project for the Israeli Navy, negotiated much of the hard metric supplies out of the final construction, saving both the shipyard and the customer excessive costs and schedule delays without jeopardizing the functionality or the quality of the vessel. This is certainly not to say that every metric requirement of the ship's specifications should be questioned, but they should be carefully examined and defined to the point that both the designers and the customer know very precisely the rules by which materials will be specified in either inch-pound or metric configuration.

Parameters for the metric material specification process should be established as part of the engineering metrics policy, balancing functionality and pricing, with full acknowledgement and approval of the customer. Ideally, the material specification process will begin at the bidding stage. At this point, the shipbuilder is in the best position to determine its ability to comply with what may be an unreasonable metric supply requirement in the specifications and negotiate it up front. NavSea's stated policy that metric components will be required unless "significant cost, schedule, or technical risk is involved" is

subject to a wide range of interpretations. The shipyard that clearly defines the extent of its metric material specifications early on in the contracting stages will go into construction much more aware of its costs and avoiding future deliberations.

The development of a shipyard's metric material specification policy should include, if it already doesn't exist, a very clear channel of communications between the material specifiers and procurement personnel. The \$500 toilet seat has become almost cliché, but it exemplifies the result of lack of communications between specifier and buyer. When dealing in the relatively new world of metric procurement, this communication becomes even more important to ensure that all potential purchases are economically viable and in compliance with the customers requirements.

Metric supplier directories are currently published by the U.S. Metric Association, The Association of Manufacturing Technology, and the General Services Administration (Appendix 1). These provide a general listing of metric materials, components, and services available domestically and should be made available to engineering and procurement staff.

6.1.2 Production Trades

If there are any preconceived notions in this country about metrication of U.S. manufacturing, probably the most prevalent is that the production trades would present a major obstacle in terms of workforce resistance and retooling. Companies and industries that have converted to the metric system have generally found this not to be the case. Approached with the appropriate rationale, motivation, and training, production workers have adapted very easily to the metric system and in most cases companies have reported favorable productivity results. Retooling, likewise has not been a major factor in the conversion process.

The same elements required for setting engineering metrication policy are entirely applicable for production trades. For the most part, engineering policy will, to a great

The shipyard that clearly defines the extent of its metric material specifications early on in the contracting stages will go into construction much more aware of its costs and avoiding future deliberations.

Approached with the appropriate rationale, motivation, and training, production workers have adapted very easily to the metric system and in most cases companies have reported favorable productivity results.

degree drive production policy via the drawings they produce for use by the trades. As stated previously, engineering's metrication policy and standards should be made available to all users of the drawings. Beyond that, the production trades will want to supplement them with job-specific guidelines that address real world situations, such as recalibration, adaptation, or replacement of measurement sensitive equipment, conversion factors for various operations, and the prevention of conversion related safety hazards. An ideal forum for the development of at least some of these guidelines is the Metric Application Training (Section 4.2.3), where the potential users of the guidelines will help to identify problem areas and create solutions for them. The appointment of a metric coordinator to oversee the transition in the production trades should be part of the metric policy.

Safety is an area that should be given particular attention, due to the potential for confusion of units from one system to the other.

Safety is an area that should be given particular attention, due to the potential for confusion of units from one system to the other. Incorrect units applied to fluid pressures and material handling equipment capacities are typical of potential confusion which must be addressed in very certain terms, with specific When guidelines distributed to all personnel affected and, in many cases, placards on the equipment.

Material handling equipment (cranes, fork lifts, chain jacks, dollies, winches, etc.) is generally insensitive to the units of measurement used, but it is critical that load limits be stated in metric units as well as the inch-pound equivalents. Of particular importance is the recognition of the difference between the inch-pound short ton and the metric ton. A confusion between the two could result in a 10% greater load than anticipated. Operator training, consistent use of metric units, and carefully placed signage are fundamental in preventing equipment overload.

Buildings, ways, and yard layouts should be redimensioned in metric units to facilitate planning and material movements. If these arrangements are on a CAD system the conversion will require a minimum of effort.

Hand tools consisting of metric tape measures, calipers, and wrenches will have to be obtained, either by the company or as part of the production workers' toolbox.

The company's metrication policy should take into consideration the expense to the employees of this retooling and work out an equitable arrangement for the purchase of new tools.

6.1.3 Support Trades

Most effected among the support trades will be those dealing with metric material, or as is more likely the case, a combination of metric and inch-pound material.

Purchasing's procurement of metric materials and components will be dictated mostly by engineering's material list, which, it is assumed will have been prepared in accordance with a clearly defined policy. It will be purchasing's challenge to identify suppliers of those metric products and procure them under reasonable terms.

The directories of metric suppliers listed in Section 3.7.1.4 should be made part of purchasing's reference library and updated continuously. As the supplier base expands, metric products will become less of a "specialty" and competition will tend to expand selection and provide more negotiating room for the buyer. These directories are for general manufacturing supplies and will not likely include much in the line of specialized shipboard equipment in metric configuration. Suppliers for these items should be listed separately or flagged as such in purchasing's database of suppliers for future reference.

Metric policy for purchasing should go beyond mere compliance with the metric requirements handed down by the contract. Material specifiers should look upon this as an opportunity to expand their vendor base to include metric suppliers for those items which had been traditionally procured in inch-pound configuration - even if the contract does not require metric configuration for them. If a metric product fulfills all the requirements of the material specification at competitive terms, there is every reason to consider it as a purchase candidate, regardless of its units of measure.

The company's metrication policy should take into consideration the expense to the employees of this retooling and work out an equitable arrangement for the purchase of new tools.

Metric policy for purchasing should go beyond mere compliance with the metric requirements handed down by the contract. Material specifiers should look upon this as an opportunity to expand their vendor base to include metric suppliers for those items which had been traditionally procured in inch-pound configuration - even if the contract does not require metric configuration for them.

More importantly than ever, communication between the material specifier and the buyer should be stressed to ensure that any pricing or delivery premium is justified.

More importantly than ever, communication between the material specifier and the buyer should be stressed to ensure that any pricing or delivery premium is justified.

As a shipyard transitions from inch-pound to metric design and construction, it is inevitable that it will have to deal with a dual inventory of certain materials. For most line item components such as pumps, valves, controllers, and fans this will not present much of a problem since these are usually specifically designated for a specific hull or installation, leaving little chance for confusion. However, bulk materials such as fasteners and plate which tend to lose their identity upon leaving inventory and have a wide range of applications, the potential for mix-up is much greater. Ideally, material specifications will standardize throughout the ship's construction on one system of measurements or the other, but in reality it is a certainty that both systems will exist simultaneously on the same contract, at least in the foreseeable future. Standards must be established for identifying and handling both inch-pound and metric based materials such that they are processed and installed as intended.

Most other administrative functions (planning, accounting, program management, etc.) will not be greatly affected by a transition to metric usage other than the requirement to obtain a thorough understanding of the metric system as it applies to their operations. Recalibration of computer programs will be necessary and desirable for some applications. Many already have metric capability built in, the rest of which will require reprogramming or the installation of conversion software.

The use of metric paper and envelope sizes is an issue which is best left unaddressed unless a contract calls for it or the company wants to forge ahead on its own. Even in highly metricized organizations, the use of metric stationary is slow to catch on and despite its apparent simplicity, it does require a relatively minor investment in modifications to some printers and copiers.

6.2 INDUSTRY POLICY

Metriation of the U.S. shipbuilding industry will happen as the result of market demand (foreign and U.S. government) and supply economics on a shipyard by shipyard basis. This has been the case in other industries, where economic and competitive factors have provided the impetus for individual companies to metricate, but industry-wide organizations have had a secondary role in setting policy for their constituents.

One example of an industry-wide organization facilitating metriation is the National Institute of Building Sciences (NIBS), a nonprofit, nongovernmental organization consisting of both private and government members representing the federal construction industry, which serves as an authoritative coordinator on issues of building science and technology. NIBS created the Construction Metriation Council to "provide industry-wide, public and private sector support for the metriation of federal construction and for the adoption and use of the metric system of measurement as a means of increasing the international competitiveness, productivity, and quality of the U.S. construction industry.". As a primary function, the Construction Metriation Council provided a forum upon which issues of metriation could be resolved by all concerned parties. Recognizing the need for communications at all levels of the industry, it initiated a bi-monthly newsletter to members, explaining the transition to metrics, updating them on recent developments, and providing basic usage rules for metrics on the job. They have also prepared a metric guide for federal construction that provides consistent rules for the use of the metric system among its members. Neither NIBS nor the Construction Metriation Council is driving the transition to metrics - the federal government with its \$40 billion annual budget and metriation mandates is, without a doubt the motivator. The industry's Metriation Council is acting as a facilitator to ensure that metric procurement requirements are reasonable and that consistency is maintained as the industry's members' respond to the government's requirements. Response by the members to these initiatives has been reported as overwhelmingly positive.

"Although the transition may be possibly disruptive to some in the short-term, the long term competitive benefits to manufacturers of moving to the metric system are overwhelming."
National Association of Manufacturers

As an industry organization dealing primarily in technical issues likely to be affected by metrication, the NSRP is in a position to assume a facilitating role to ensure that its members' interests, both private and public are represented and reconciled at the industry level in a positive manner.

NIBS is an ideal example in this context since it appears to very closely parallel the NSRP in make-up and function and the fact that much of its members' work comes from the federal government. In response to the shipbuilder survey, 77% of the respondents stated that the U.S. shipbuilding industry as a whole should take a proactive role regarding metrication. Asked which industry organization would be most appropriate to facilitate industry metrication, 46% of the respondents named the NSRP as their first choice, which was double the next highest candidate.

Just as individual shipyards need high level management commitment to make a successful transition to metrics, so does the industry. Currently, the industry's largest customer is preparing to release future contracts with metric requirements. Shipbuilders have had very little input and as individual bidders and contractors, they will continue to have very little to say about the way metric requirements are specified. As an industry organization dealing primarily in technical issues likely to be affected by metrication, the NSRP is in a position to assume a facilitating role to ensure that its members' interests, both private and public are represented and reconciled at the industry level in a positive manner.

7.0 CONCLUSIONS & RECOMMENDATIONS

Section 3.1 presented two conclusions upon which the industry perspective was developed:

1. There are significant forces which are driving U.S. manufacturing industry toward metrication.
2. The U.S. and almost all of its commerce is currently dealing in a "hybrid" metric environment - a constantly varying and inconsistent mixture of inch-pound and metric measures.

With these global conclusions as premises, the issues of metrication were explored from the shipbuilding perspective, resulting in the following industry-specific conclusions:

1. Market demand will be the No. 1 driving force behind shipbuilding metrication, occurring mainly in the U.S. government and foreign market sectors. There is much apparent motivation by shipbuilders to convert to metrics just for the inherent logic and simplicity of it, but so far none have been willing to commit to the change on their own, unless a contract calling for metrics was in hand or imminent. While market demand is the primary force behind U.S. shipbuilding metrication, it is unlikely that a shipbuilder's metric design and construction capability will sell any ships. Rather, it will simply allow it to participate in a broader array of markets.
2. The supply of metric materials is an impeding factor, but not prohibitively so. Most common raw materials and components are readily available in hard or soft metric configuration at competitive terms with inch-pound equivalents. Order quantities and commonality of use with other industries will be a major factor in determining pricing and delivery for most metric shipbuilding materials such as steel and fasteners. Metrics should not be an overriding factor in material specification and procurement decisions. Although it is desirable to tend toward metric products wherever feasible, functionality and economics must continue to be the primary drivers. U.S. shipbuilding is not in a

Market demand will be the No. 1 driving force behind shipbuilding metrication, occurring mainly in the U.S. government and foreign market sectors.

The supply of metric materials is an impeding factor, but not prohibitively so.

position to break ground in the procurement of new metric supplies if cost and delivery penalties put them at a competitive disadvantage. As U.S. suppliers make the transition to metric products due to general market forces, U.S. shipbuilders should be poised to take advantage of the movement. A shipbuilder may well find a competitive advantage by expanding its base of supplies to include metric products.

Fears of massive disruptions and rework due to the introduction of metrics in a manufacturing environment have not been substantiated by experiences in other industries.

The non-recurring costs of converting to metric design and construction can be less than 2% of a lead ship's contract value.

The industry needs a facilitator to help formulate consistent metrication policy. The NSRP is in a position to fulfill that role...

3. Fears of massive disruptions and rework due to the introduction of metrics in a manufacturing environment have not been substantiated by experiences in other industries. The most successful transitions have been in those companies which made a high level commitment to metrication and planned and trained adequately.
4. The non-recurring costs of converting to metric design and construction can be less than 2% of a lead ship's contract value. This assumes a rational approach to the transition and that metric supplies will be selected and procured on the same basis as their inch-pound counterparts, ie; cost, delivery, and functionality. Subsequent metric ship projects will incur minimal, if any conversion costs and benefits will continue to accrue.
5. The industry needs a facilitator to help formulate consistent metrication policy. The NSRP is in a position to fulfill that role and it is recommended that the Executive Control Board place on their agenda the issue of metrication, with the following items of discussion:
 - A. The acceptance (with or without modifications) of the conclusions and recommendations of this report, leading to an official NSRP policy on metrication. This policy should be communicated to the Shipbuilders Council of America, the American Waterways Operators, and other industry organizations for comment and endorsement. The resulting industry policy should be publicized through news releases and articles in trade publications and other means. To expedite this initiative, a draft policy statement is included as Appendix K to serve as a starting point for discussion.
 - B. The establishment of a shipbuilding metrication council to identify and seek resolution of emergent

issues of metrication affecting a broad spectrum of the industry.

- C. The compilation of a directory(ies) of metric shipbuilding supplies, services, equipment, and standards. These may be based upon existing general metric supplier directories, but expanded to include specialized items used by the shipbuilding industry. An interactive database should be considered, whereby shipyards and metric suppliers contribute data.
- D. The development of a manual of metrication application guidelines for the shipbuilding trades, with particular attention paid to the safety aspects of transition. The manual can be derived from existing standards and industry publications, tailored to suit the shipbuilding trades in accordance with the policy established in (A) above.
- E. The development of a modular metrics training course for the shipbuilding trades. Included as part of this item would be a course outline, handouts, and audio-visual aids.

All of the above can be accomplished within the current structure of the NSRP, with minimal expenditures. If and when the National Shipbuilding Initiatives are developed to a functional level, metrication should be embedded as an issue in all those that are relevant.

Despite the seemingly sluggish pace of acceptance, there is a strong undercurrent of forces driving this country toward metrication. Congress sees it as one of many initiatives to maintain and improve global competitiveness of American industry. The federal government's procurement policies are being used as both a stick and a carrot to achieve that objective. In addition, the private sector is starting to realize that global markets provide a real opportunity to grow and prosper. The metrication of U.S. industry will probably maintain its current pace until such time that a combination of government, regulatory, and market forces reach a critical mass, at which time the transition will happen in a relatively rapid manner. This is likely to occur within the next three years, certainly before the end of the decade. For some shipbuilders it will happen as soon as their next contract. For those companies who

For those companies who have prepared for it, the cost and disruption of transition will be minimal. For those that have not prepared for it or resist it, the transition could be chaotic and costly.

have prepared-for it, the cost and disruption of transition will be minimal. For those that have not prepared for it or resist it, the transition could be chaotic and costly.

While planning, training, and resource commitment at the shipyard level are absolutely essential to a conversion to metrics, a strong industry-level policy forum will be highly beneficial in rationalizing metric requirements and providing consistent guidance to its members.

7.1 TABLE OF RECOMMENDATIONS

Table 2 lists recommended actions for the implementation at the shipyard level, while Table 3 lists industry level recommendations. The recommendations are listed in order of priority and sequentially. While industry wide actions are separated from company initiatives, they should be coordinated to ensure consistency of implementation and constructive feedback. The recommended actions are detailed in the sections noted in parentheses.

TABLE 2
U.S. SHIPBUILDING METRICATION
SHIPYARD LEVEL RECOMMENDATIONS

NO.	ACTION	RESPONSIBILITY P = PRIMARY S = SECONDARY
1.	Draft metrication policy for the shipyard based upon projected customer base and overall company goals and strategies (Section 6.1).	P - Upper Management S - Mid Management
2.	Assign responsibilities for identifying and assessing the implications of metrication in all affected functions of the shipyard.	P - Upper Management S - Mid Management
2a.	Determine training needs (Section 4.2).	P - Human resources S - Department heads
2b.	Determine facility/equipment needs (Section 4.3, 6.1.2).	P - Indust. Engineering S - Department heads
2c.	Determine Engineering needs (Section 6.1.1).	P - Eng'g Dept. head S - Dept. personnel
2d.	Determine Purchasing needs (Section 6.1.1.3, 6.1.3).	P - Purch'g Dept. head S - Dept. personnel
3.	Develop action plans for each affected functional area of the shipyard, outlining the specific actions required to support the metrication policy (Section 6.1).	P - Mid Management S - Dept. personnel
4.	Coordinate all action plans and estimate costs and schedules (Section 5.0)	P - Mid Management S - Acct'g, Planning
5.	Review, revise as necessary, and approve action plan as part of the shipyard's strategic plan.	P - Upper Management S - Mid Management
6.	Assign metric monitor(s) and begin implementation.	P - Upper Management S - Metric Coordinator
7.	Monitor implementation and adjust as required.	P - Metric Coordinator S - Mid Management

TABLE 3
U.S SHIPBUILDING METRICATION
INDUSTRY LEVEL RECOMMENDATIONS

NO.	ACTION	RESPONSIBILITY P = PRIMARY S = SECONDARY
1a.	Review, revise and accept the conclusions of this report and draft a policy statement on industry metrication (Section 6.2, 7.0, Appendix K).	P - NSRP Executive Control Board (ECB) S - NSRP Panels
1b.	Seek consensus agreement of the draft metrication policy from Shipbuilders Council of America, American Waterways Operators - Shipyard Conference, suppliers, government agencies: and other materially affected interests.	P - ECB
1c.	Publicize industry policy via news releases, magazine articles, and symposia presentations.	P - Panel SP-6 S - All NSRP Panels
2a.	Define objectives and practices for coordinating industry /government metric transition for shipbuilding.	P - ECB S - NSRP Panels
2b.	Solicit support from all affected interests.	P - ECB S - NSRP Panels
2C.	Sponsor organizational meeting of a shipbuilding <u>Metrication Gouncil</u> (Section 6.2)	P - ECB S - Panel SP-6
3.	Compile directory(s) of metric suppliers, services, software, and standards (Section 7.0).	P - Panel SP-6 S - ECB (approval)
4.	Develop course outline and training materials for shipbuilding trades (Section 7.0)	P - Panel SP-9 S - ECB (approval)
5*	Develop metrication application guidelines for the shipbuilding trades (Section 7.0).	P - NSRP Panels S - ECB (approval)

REFERENCES:

¹U.S. industrial Outlook, - Shipbuilding and Repair, U.S. Dept. of Commerce Bureau of Economic Analysis, 1993, p. 21-1

²Ibid., p. 21-6

³ **Five Year Outlook for the U.S. Marine Industry**, IMA Associates Inc., p. 1-2

⁴ Ibid. (1), p. 21-5

⁵ **DDGX Producibility Study, Hybrid, Metric Design Assessment**, Lockheed Shipbuilding and Construction Company, Naval Sea Systems Command, 1982, p. 4-1

⁶ **Metrication in Ship Design and Construction**, Ingalls Shipbuilding, Naval Sea Systems Command, 1982, p. 2-2

⁷ **Metric Transition Plan**, Maritime Administration, Dept. of Transportation, 1992, p.5

⁸ **Metric Guide for Federal Construction**, National Institute of Building Sciences, 1991, p. 4

⁹ **Metric Today**, U.S. Metric Association, Sept.-Oct. 1991, p. 4

Appendix A

Executive Order 12770, Metric Usage in Government Programs

Presidential Documents

Executive Order 12770 of July 25, 1991

Metric Usage in Federal Government Programs

By the authority vested in me as President by the Constitution and the laws of the United States of America, including the Metric Conversion Act of 1975, Public Law 94-168 [15 U.S.C. 205a et seq.] ("the Metric Conversion Act"), as amended by section 5164 of the Omnibus Trade and Competitiveness Act of 1988, Public Law 100-418 ["the Trade and Competitiveness Act"], and in order to implement the congressional designation of the metric system of measurement as the preferred system of weights and measures for United States trade and commerce, it is hereby ordered as follows:

Section 1. Coordination by the Department of Commerce. [a] The Secretary of Commerce ("Secretary") is designated to direct and coordinate efforts by Federal departments and agencies to implement Government metric usage in accordance with section 3 of the Metric Conversion Act (15 U.S.C. 205b), as amended by section 5184(b) of the Trade and Competitiveness Act.

(b) In furtherance of his duties under this order, the Secretary is authorized

[1] to charter an Interagency Council on Metric Policy ("ICMP"), which will assist the Secretary in coordinating Federal Government-wide implementation of this order. Conflicts and questions regarding implementation of this order shall be resolved by the ICMP. The Secretary may establish such subcommittees and subchairs within this Council as may be necessary to carry out the purposes of this order.

(2) to form such advisory committees representing other interests, including State and local governments and the business community, as may be necessary to achieve the maximum beneficial effects of this order; and

[3] to issue guidelines, to promulgate rules and regulations, and to take such actions as may be necessary to carry out the purposes of this order. Regulations promulgated by the Secretary shall function as policy guidelines for other agencies and departments.

(c) The Secretary shall report to the President annually regarding the progress made in implementing this order. The report shall include:

[1] an assessment of progress made by individual Federal agencies towards implementing the purposes underlying this order;

[2] an assessment of the effect that this order has had on achieving the national goal of establishing the metric system as the preferred system of weights and measures for United States trade and commerce and

[3] on October 1, 1992, any recommendations which the Secretary may have for additional measures, including proposed legislation, needed to achieve the full economic benefits of metric usage.

Sec. 2. Department and Agency Responsibilities. All executive branch departments and agencies of the United States Government are directed to take all appropriate measures within their authority to carry out the provisions of this order. Consistent with this mission, the head of each executive department and agency shall:

(a) use, to the extent economically feasible by September 30, 1992, or by such other date or dates established by the department or agency in consultation with the Secretary of commerce, the metric system of measurement in Federal Government procurements, grants, and other business-related activi-

ties. Other business-related activities include all use of measurement units in agency programs and functions related to trade, industry, and commerce.

(1) Metric usage shall not be required to the extent that such use is impractical or is likely to cause significant inefficiencies or loss of markets to United States firms.

(2) Heads of departments and agencies shall establish an effective process for a policy-level and program-level review of proposed exceptions to metric usage. Appropriate information about exceptions granted shall be included in the agency annual report along with recommendations for actions to enable future metric usage.

(b) seek out ways to increase understanding of the metric system of measurement through educational information and guidance and in Government publications. The transition to use of metric units in Government publications should be made as publications are revised on normal schedules or new publications are developed, or as metric publications are required in support of metric usage pursuant to paragraph (a) of this section.

(c) seek the appropriate aid, assistance, and cooperation of other affected parties, including other Federal, State, and local agencies and the private sector, in implementing this order. Appropriate use shall be made of governmental, trade, professional, and private sector metric coordinating groups to secure the maximum benefits of this order through proper communication among affected sectors.

(d) formulate metric transition plans for the department or agency which shall incorporate the requirements of the Metric Conversion Act and this order, and which shall be approved by the department or agency head and be in effect by November 30, 1991. Copies of approved plans shall be forwarded to the Secretary of Commerce. Such metric transition plans shall specify, among other things:

(1) the total scope of the metric transition task for that department or agency, including firm dates for all metric accomplishment milestones for the current and subsequent fiscal year:

(2) plans of the department or agency for specific initiatives to enhance cooperation with industry, especially small business, as it voluntarily converts to the metric system, and with all affected parties in undertaking the requirements of paragraph (a) of this section and

(3) specific steps and associated schedules through which the department or agency will seek to increase understanding of the metric system through educational information and guidance, and in department or agency publications.

(e) designate a senior-level official as the Metric Executive for the department or agency to assist the head of each executive department or agency in implementing this order. The responsibilities of the Metric Executive shall include, but not be limited to:

(1) acting as the department's or agency's policy-level representative to the ICMP and as a liaison with other government agencies and private sector groups:

(2) management oversight of department or agency outreach and response to inquiries and questions from affected parties during the transition to metric system usage; and

(3) management oversight of preparation of the department's or agency's metric transition plans and progress reports, including the Annual Metric Report required by 15 U.S.C. 205j and OMB Circular A-11.

(4) preparation by June 30, 1992, of an assessment of agency progress and problems, together with recommendations for steps to assure successful implementation of the Metric Conversion Act. The assessment and recommendations shall be approved by the head of the department or agency and provided

to the Secretary by June 30, 1992, for inclusion in the Secretary's October 1, 1992, report on implementation of this order.

Sec. 3. Application of Resources. The head of each executive department and agency shall be responsible for implementing and applying the necessary resources to accomplish the goals set forth in the Metric Conversion Act and this order.

Sec. 4. Judicial Review. This order is intended only to improve the internal management of the executive branch and is not intended to create any right or benefit, substantive or procedural, enforceable at law by a party against the United States, its agencies, its officers, or any other person.



THE WHITE HOUSE
July 25 1991.

[FR Doc. 01-180028
Filed 7-25-91; 3:06pm
Billing code 3195-01-M]

Appendix B

DoD Instruction 5000.2

APPENDIX B

Feb 23, 91
5000.2, PART 6
SECTION M

PART 6

SECTION M

USE OF THE METRIC SYSTEM

- References:
- (a) DoD Directive 4120.18, "DoD Metrication Program," September 16, 1987 (Canceled)
 - (b) Title 15, United States Code, Sections 205a-205k, "Metric Conversion"
 - (c) Federal Register, "The Metric System of Measurement," February 26, 1982
 - (d) STANAG-4183, "NATO Metrication Policy"
 - (e) MIL-STD-961, "Preparation of Military: Specifications and Associated Documents"
 - (f) MIL-STD-962, "Preparation of Military: Standards and Handbooks"

1. PURPOSE

- a. This section replaces DoD Directive 4120.18, "DoD Metrication ProgramTM (reference (a)), which has been cancelled,
- b. These policies and procedures support the U.S. national *effort to* convert to their metric system.
- c. This section implements Title 15, United States Code, Sections 205a-205k, "Metric Conversion" (reference (b)).

2. POLICIES

The metric system of measurement, as interpreted for use in the United States by "The Metric System of Measurement" issued by the Secretary of Commerce in the February 26, 1982 Federal Register (reference (c)) shall be used by all DoD activities, including *all those* elements of defense systems requiring new design, as required by Title 15, United States Code, Sections 205a-205k, "Metric Conversion" (reference (b)).

3. PROCEDURE

a. Waivers and Exceptions

- (1) Milestone decision authorities may grant waivers on a case-by-case basis if the use of the metric system is not in the best interest of the Department of Defense.
- (2) The measurement units in which a system was originally designed will be retained for the Life of the system, unless the procuring activity determines it is more advantageous to convert to the metric system.

- b. Compatibility. Physical and operational interfaces between metric and inch-pound items will be designed to ensure compatibility.
- C. Hybrid Designs. During the metric transition phase, use of hybrid metric and inch pound design may be necessary, and are acceptable.
- (1) Items of commercial design will be specified in metric units when economically available and technically adequate, or when otherwise determined by the procuring activity to be in the best interest of the Department of Defense.
 - (2) Bulk materials will be specified and accepted in metric units, unless being acquired for use in materiel designed in inch-pound units.

New Equipment When purchasing new shop, laboratory, and general Purpose test equipment, the equipment must be capable of in metric; or both metric and inch-pound units.

Additional guidance. Additional guidance is contained in NATO MIL-STD-961, and MIL-STD-962 (references (d), (e), and (f)).

4. RESPONSIBILITIES AND POINTS OF CONTACT

The matrix below identifies offices to be contacted for additional information on this section. The full titles of these offices may be found in Part 14 of this Instruction.

<u>DoD Component</u>	Points of contact	
	General	Specific
OSD	ASD(P&L)	DASD(PR)/SDM
Dept of Army	ASA(RDA)	SARD-DE
Dept of Navy	ASN(RDA)	Dep, APIA
Dept of Air Force	ASAF(A)	SAF/AQX
Other DoD Components	DLA	DLA-SE

Appendix C

**DoD/Navy Metric Systems and Subsystems listed in Reports to Congress
(FY '88-'91)**

METRIC SYSTEMS AND SUBSYSTEMS LISTED IN REPORTS TO CONGRESS (FY 88 THROUGH FY 91)

I. IN PRODUCTION PHASE

METRIC WEAPON SYSTEMS:

ARMY

Hellfire Missile System
Multiple Launch Rocket System (MLRS)
Family of Medium Tactical Vehicles (FMTV) (Light and Medium Vehicles and Trailers)
M1000, 20-Ton Semi-Trailer
120-mm M285 Mortar
Medium Girder Bridge (70 percent)
M9 Pistol
M230 Machine Gun
M240 Machine Gun
M242 Machine Gun
M249 Machine Gun
M901 Ctg. 25-mm APFSDS-T
M788 Ctg. 30-mm TP
M789 Ctg. 30-mm TP
M789 Ctg. 30-mm Hi-Explosive Dual Purpose (HEDP)
M788 Ctg. 30-mm Target Practice
M848 Ctg. 30-mm Dummy
M883 Ctg. 30-mm Hi Pressure Test
XM977 TP-T Ctg. 30-mm Target Practice with Trace
Army Tactical Missile Systems (ATACMS), ATACMS Peculiar Design Hardware
M22 7x50 Binoculars
GUARDFIST II Artillery Trainer (25 percent)
GUARDFIST II Armor Trainer (40 percent)
Data Automated Tower Simulator (DATS) (25 percent)
Ribbon Bridge Erection Boat (30 percent)
M120 - 120-mm MORTAR - Towed (listed last year in RDT&E Phase)
M121 - 120-mm MORTAR MECH Carrier (listed last year in RDT&E Phase)
M910 Ctg., 25-mm TPDS-T
M789 Ctg., 30-mm Hi-Explosive Dual Purpose (HEDP)

NAVY

MK-74 Mod O Versatile Exercise Mine System (VEMS)
Utility Boat, 15 meter
Utility Boat, 10 meter
Safety of Life at Sea (SOLAS) Boat, 9.4 meter
MK 214 Mod O NATO SEA GNAT RF Seduction Decoy TDP Dimensions in Millimeters and Inches, ACAT III
MK 216 Mod O NATO SEA GNAT RF Distraction Decoy TDP Dimensions in Millimeters and Inches, ACAT III

AN/SLQ-49 Rubber Duck Decoy, ACAT III
Resuscitation Fluids Production and Reconstitution System (REFLUPS)
YR 90 Repair Barge
AN/SLQ-49 Rubber Duck
MK 214 NATO Sea Gnat Chaff
MK 216 NATO Sea Gnat Chaff

MARINE CORPS

Mobile Electronic Warfare Support System (MEWSS) (AN/MLQ-36)
Combat Excavator
Communication Central, AN/MSC-63A
M1A1 Main Battle Tank (Outside Only)
TOW (Army Contract)
Javelin (Army Contract)
Riverine Assault Craft (RAC) (also listed under RDT&E)
Special Operations Capable Vehicle (SOCV) (also listed under RDT&E)
Improved Rigid Raiding Craft (IRRC)

AIR-FORCE

Scope Shield

DERIVATIVE METRIC WEAPON SYSTEMS:*

ARMY

Tank Weapon Gunnery System (TWIGGS)
120-mm Ammunition
CAM Chemical Agent Monitor
M17 Lightweight Decontamination System
Ribbon Bridge Erection Boat 120-mm XM256 Cannon (Tank Cannon)
M-240 7.62-mm Coax as used on the Bradley Fighting Vehicle

NAVY

T-45A Trainer Aircraft
NATO Sea Sparrow Missile System (not metric, but mentioned in prior reports)
Bol Chaf EM System
MK75 76-mm Gun Mount
Electromagnetic Catapult Aircraft Launching System
MHC 51 Minehunter Ships

MARINE CORPS

Small Emplacement Excavator (SEE) Tractor
Stratified Charge Rotary Engine (SCRE)
Advanced Amphibious Assault Vehicle (AAAV)
Armored Vehicle Maintenance System (Engine Only)

AIR FORCE

None Listed

METRIC SUBSYSTEMS:*

ARMY

M772 Fuze, MTSQ for 81-mm Mortar Ammo
M776 Fuze MTSQ for 60-mm Mortar Ammo
M613 Container Ship and Store 155-mm Ammo
Army Tactical Missile Systems (ATACMS), MLRS Launcher
M-212 25-mm Automatic Gun used on Bradley Fighting Vehicle System
Fiber Container/Woodbox for 120-mm Tank Ammo
AH1 Flight Weapon Simulator
Desert Hawk Flight Simulator
Advanced Antitank Weapon System - Medium (AAWS-M) Trainer
Basic Morse Mission Trainer (BMMT)
Combined Arms Training Integrated Evaluation System (CATIES)

NAVY

AN/SQQ-32 Advanced Minehunting Sonar System - Classification Sonar Subsystems
MCS 2000 IC System
AN/URC 109 Radio Transceiver
Optical Designs for Periscopes, Type 2, 8, 15, 18, and 22
Advanced Seal Delivery Systems (ASOS)
T-AO 187 Oiler Ship, Main Propulsion Diesel Engine Systems
T-AG05 19 Surveillance Ship, Distilling Plants
T-AG 195 Acoustic Research Ship, Distilling Plants
MK 23 Target Acquisition System (TAS) (not metric, but mentioned in prior reports)
MK 6 Low-Light Level Television System (LLLTV) (not metric, but mentioned in prior reports)
F405-RR-401 Engine Program

MARINE CORPS

LAV Antitank (Chassis Only)
Unit-Level Circuit System Data Module

AIR FORCE

None Listed

DERIVATIVE METRIC SUBSYSTEMS:*

ARMY

Mobile Subscriber Equipment (about 30 percent metric)
Electric Power Plant II (about 2 percent metric)

M256 Gun, 120-mm
M1 Simulator
Target Holding Mechanism
C2 Protective Mask Canister (NDI)

NAVY

AN/UMQ-12, Mini Rawin System

MARINE CORPS

MK 18 Ribbon Bridge/Container Transporter

Air Force

None Listed

II. RDT&E PHASE

METRIC WEAPON SYSTEMS:*

ARMY

Fiber Optic Guidance Missile (FOG-M) (partially NDI – about 50 percent metric)
Forward Aerial Air Defense C2I (about 50 percent metric)
Line of Sight Forward - Heavy (about 50 percent metric)
Light Helicopter Program (Airframe and T800 Engine)
Advanced Tank Cannon System XM291
Radar Frequency Interferometer (RFI)
Heavy Dry Support Bridge (HDSB)
Light Armored Vehicle
AT4 Autonomous Metric TDP Property/Licensed to Producer CONUS with American TDP
XM120 - 120-mm MORTAR Towed
XM121 – 120-mm MORTAR MECH Carrier
– 120-mm NDI Ammo, HE Smoke Illum
XM933 Ctg. 120-mm HE w/M935 Fuze
XM934 Ctg. 120-mm HE w/M734 Fuze
xM929 Ctg. 120-mm Smoke
XM930 Ctg. 120-mm Illum
M919 Ctg. 25-mm APFSDS-T
Packaging for Target Practice Gunnery Inbore Device for 35-mm XM968, 120-mm Tank
Production
Armament Enhancement Initiative (AEI) Development
Lightweight 120-mm Program
Mobile Automated Instrumentation System (MAIS)
Close Combat Tactical Trainer (CCTT) (50 percent)
Miles Air to Air STINGER/AVENGER (75 percent)
Antitank Weapon System - Medium (AWS-M)
XM135 MLRS Binary Chemical Warhead
Army Tactical Missile System (TACMS) Peculiar Design Hardware
Follow-on to Lance
Multi Purpose Individual Munition

Ground-Based Surveillance and Tracking System (GSTS)
Ground-Based Laser
120-mm M291 Cannon (Tank Cannon), Pre-concept Stage
Kinetic Energy Anti-Satellite
Family of Light Bridging
Ground Based Surveillance and Tracking System (GSTS)
Ground Based Radar (GBR)
Ground Based Interceptor (GBI)
Endo-Exo Interceptor (Endo-Atmosphere-Exo-Atmosphere Interceptor)
Advanced Field Artillery System, Advanced Technology Transition Demonstrator (AFAS ATTD)
Combat Mobility Vehicle, Advanced Technology Transfer Demonstrator (CMV ATTD)
Block III Tank/Common Chassis, Advanced Technology Transition Demonstrator (CCATTD)
Future Armored Resupply Vehicle (FARV)
Line-of-Sight Anti-Tank (LOSAT) Weapon System (exclusive of Bradley Fighting Vehicle System Chassis)
Lightweight Forward Area Refueling Equipment
Standardized Army Refueling System
Autonomous Precision Guided Munition (APGM) International Program
Chemical Biological Mass Spectrometer

NAVY

Malfunction Radian System**
Advance Optical Sensor System
Advanced Rocket System (ARS)
Sea Pretel
NULKA Active FR Decoy TDP Dimensioned in Millimeters and Inches, ACAT III
Multifunction Information Distribution System (MIDS)
Work Boat, 15-meter
YOGN Fuel Barges
YFN Covered Lighters
Utility Boat, Barracks Craft, (APL) 12-meter
Personnel Boat, 12-meter
Personnel Boat, 10-meter
Personnel Boat, 8-meter
Harbor Security Boat, 7-meter
Photonics Mast/Navigation System
AN/SLQ-54 EMC System
AN/SQY-1 Surface Ship ASW Combat System
Launching System, Decoy, MK 53 MOD O
AN/SLQ-39 Chaff Buoy

MARINE CORPS

LAV, Air Defense
LAV, 105
Anti-personnel Obstacle Breaching System
Stratified-charge Rotary Engine
Advanced Amphibious Assault Vehicle
SRAW
Anti-magnetic Mine Actuating Device

AIR FORCE

Advanced Short Range Air-to-Air Missile
Base Recovery Vehicle
Peace Shield (Computers)
PGU-31/B Armor Piercing Round 40-mm Ammo
Multipurpose Information Distribution System
Space-Based Interceptor (SBI)
Space Surveillance and Tracking System (SSTS)
Boost Surveillance and Tracking System (BSTS)
National Aerospace Plane (with NASA)
Brilliant Eyes

DERIVATIVE METRIC WEAPON SYSTEMS:*

ARMY

Flex Pallet System
Floating Float Bridge 2000

NAVY

Phalanx WS, Transmitter Subsystem
AN/SAR -8 Infrared Search and Target Designation
Offboard Active CM

MARINE CORPS

Pathfinder Marking Device
Team Portable Communication Intelligence System (TPGS) "Tophunter"
Technical Control and Analysis Center (TCAC)

AIR FORCE

HB 876 Aerial Denial Mine Direct Airfield Attack Combined Munition

*METRIC SUBSYSTEMS:**

ARMY

Pedestal Mounted STINGER (mostly NDI - about 10 percent metric)
Army Unmanned Aerial Vehicle (AUAV) Recovery Subsystem
AUAV Air Vehicle Handler Crane
AUAV Air Vehicle Engine (about 5 percent metric)
Leguan Bridge Tank Chassis (about 20 percent metric)
Connectors for Composite Bridging
SLEKE Projectiles
EMAT Launcher
Li/Ms Battery
Ultra Capacitor
EM Rail Skid-Gun

EM Coil Skid Gun
UT-CEM Lab Gun
Coilgun Armature Development
Decontaminating Agent, Multipurpose (6.2 RDTE)
Modular Decontaminating System (Engine Only)
SEAC HOMO Polar Generator
EHV Electromagnetic Accelerator
90-mm Multi-Shot Railgun Barrel
Lab ETC Launcher
65 MJ Power Supply
Regenerative Liquid Propellant Gun (RLPG) No. 3
Gun Mount for RLPG No. 3
LOSAT Weapon Module (Missile and Launch Pad)
Search Radar, Line of Sight-Forward-Heavy
Missile with Canister, Line of Sight-Forward-Heavy
Air Ground Engagement System II (AGES II)
Combined Maneuver Training Center (CMTC)
Firefinder
Mobile Automated Instrumentation System (MAIS)
Guard Unit Armory Device Training - Artillery (Guardfist II)
Guard Unit Armory Device Training - Armor (Guardfist I)

NAVY

Laser Detection and Sampling System (Hazardous Gases)
Fiber Optic Integrated Voice Communication System
Advanced Optical Censor System (AOSS)
High-Speed Optical Network
Power System Processor, MK 174, MOD 1
Processor, Decoy Launch, MK 24, MOD 1
Launcher, Electronic Decoy, MK 169, MOD O
Processor, Casualty, Decoy Launch, MK 25
Cartridge, Electronic Decoy, MK 234, MOD O

MARINE CORPS

Electronic Intelligence Support System (ESS)
Mobile Electronic Warfare Support System (MEWSS) (AN/MLQ-36)
Riverine Assault Craft (RAC)
Special Operations Capable Vehicle (SOCV)

AIR FORCE

Milstar Ground Control Segment
Small ICBM Ordnance Fire (cancelled in 1992)

DERIVATIVE METRIC SUBSYSTEMS:*

ARMY

Folding Float Bridge (FFB) 2000, Bridge Bays (90 percent metric)
Folding Float Bridge (FFB) 2000, Launcher (30 percent metric)

Leguan Bridge (Bridge)
Leguan Bridge (Launcher)

NAVY

Portable Diesel Fire Pumps for ship rescue and salvage
Marine-Salvage Lift Bags

MARINE CORPS

None Listed

AIR FORCE

None Listed

* A metric weapon system (or subsystem) is one for which the contract required the system be designed using the metric system of measurement with or without exceptions being authorized for use of existing nonmetric components or allowing use of nonmetric world standards such as inches for electronics.

A derivative metric weapon system (or subsystem) is one for which the design was derived from an existing metric system, such as a modified version of a foreign weapon system.

** In this system, the system specification encourages the use of metric dimensioning and tooling. The use of a "hard" metric MIL specification will be evaluated during full-scale development. The equipment display will be capable of being readily switched during calibration to SI units.

METRIC SYSTEMS - FY 1992
(Systems and Subsystems not listed in previous annual reports)

I. IN PRODUCTION PHASE

METRIC WEAPON SYSTEMS: *

ARMY

M910 Ctg., 25-mm TPDS-T
M789 Ctg., 30-mm Hi-Explosive Dual Purpose (HEDP)
Aircrew Protective Mask
Advanced Aviation Forward Area Refueling
Breather System (exclusive of Abrams chassis)
Mobile Over Snow Transport
Snowmobile/Sled
Desert Mobility Vehicle System

NAVY

Transportable Recompression Chamber System
12-m Utility Boat (formerly listed under RDT&E)
8-m Personnel Boat (formerly listed under RDT&E)
10-m Personnel Boat (formerly listed under RDT&E)
12-m Personnel Boat (formerly listed under RDT&E)
15-m Work Boat (formerly listed under RDT&E)
10-m NSW Rigid Inflatable Boat (RIB)
11-m Landing Craft
D-46/ALE-39 Bol-Chaff Dispenser
Penguin MK2 Mod 7 Program
Advanced AYK-14 Standard Airborne Computer
ARC-210 ECCM Combo Radio
Standard Attitude Heading Reference System (SAHRS)
Solid State Barometric Altimeters (SSBA)

MARINE CORPS

None listed

AIR FORCE

None Listed

DERIVATIVE METRIC WEAPON SYSTEMS: *

ARMY

M120 - 120-mm MORTAR – Towed (listed last year under MWS)
M121 - 120-mm MORTAR MECH Carrier (listed last year under MWS)
XM933 Ctg., 120-mm HE w/M935 Fuze (formerly listed as MWS under RDT&E)
XM934 Ctg., 120-mm HE w/M734 Fuze (formerly listed as MWS under RDT&E)
XM929 Ctg., 120-mm Smoke (formerly listed as MWS under RDT&E)
XM930 Ctg., 120-mm Illum (formerly listed as MWS under RDT&E)

NAVY

Versatile Exercise Mine System (VEMS) (formerly listed under Metric Weapon System under Production)

MARINE CORPS

Shoulder Launched Multi-Purpose Assault Weapon (SMAW)

AIR FORCE

T-1A Training System (Purchase of Commercial Off-the-shelf Beach 400T business jet)

METRIC SUBSYSTEMS:*

ARMY

M-212 25-mm Automatic Gun used on Bradley Fighting Vehicle System
Fiber Container/Woodbox for 120-mm Tank Ammo
AHI Flight Weapon Simulator
Desert Hawk Flight Simulator
Advanced Antitank Weapon System - Medium (AAWS-M) Trainer
Basic Morse Mission Trainer (BMMT)
Combined Arms Training Integrated Evaluation System (CATIES)

NAVY

None Listed

MARINE CORPS

None Listed

AIR FORCE

Scope Shield (formerly listed under Metric Weapon System in Production)

Combat Weather System

Weapon Storage and Security System

Base and Installation Security System/electronic Security Equipment

DERIVATIVE METRIC SUBSYSTEMS:*

ARMY

M776 MTSQ 60-mm Mortar Fuze

NAVY

Portable Air Compressors for Rescue and Salvage (Engine Only)

AN/SQQ-32 Advanced Minehunting Sonar (Classification Sonar) (formerly listed under Metric Subsystems under Production)

MARINE CORPS

None Listed

AIR FORCE

C-17 Tail Stand (P/N17G113055-1)

II. RDT&E PHASE

METRIC WEAPON SYSTEMS:*

ARMY

Theatre High Altitude Area Defense (THAAD) System

NAVY

Submarine Rescue Diving & Recompression System (SRDRS)

17-m Target Drone

9-m Towed Target

11-m Workboat

7-m Rigid Inflatable Boat (RIB)

Mine Countermeasure Systems

Swedish American Minesweep II

Advanced Lightweight Influence Sweep System

Explosive Neutralization System

Distributed Explosives Technology

Shallow Water Assault Breaching System
Obstacle Breaching System
Breach Lane Navigation System
Buried Mine Detector (Advanced Development Model)
Airborne Low Frequency Sonar (ALFS) (Reeling Machine including
control unit, interface unit, and transducer subsystems)

MARINE CORPS

25-mm Advanced Multi-Purpose Program

AIR FORCE

Space Integrated Control Experiment

DERIVATIVE METRIC WEAPON SYSTEMS:*

ARMY

Floating Float Bridge 2000
Improved Ribbon Bridge Transporter (IRBT)

NAVY

None Listed

MARINE CORPS

None Listed

AIR FORCE

None listed

METRIC SUBSYSTEMS:*

ARMY

Nine Mega Joule Lab Gun
Focused Technology Program
Etc Poise Power Module
Small Caliber EM Demonstrator
Ducted Rocket Engine Cooperative Program with Japan
EM230 (Unicharge) Propelling Charger
XM46 (Liquid Propellant) Propelling Charge

NAVY

AN/SSN-2 Precise Integrated Navigation System (PINS) Phase III
(AN/UYK-44 Tactical Display Mathematical Algorithms)
AN/SLQ-53 Single Ship Deep Sweep (SSDS) (Winch Only)
Shipboard GPS Fiber Optic Antenna Link

MARINE CORPS

None Listed

AIR FORCE

SHIELD (Staring Hybrids)
STAR (Electromagnetic Sensors)
SHADOW (Staring Hybrids)
IR Focal Plane Arrays Hardening Concepts)
Long Wave IR Detector Arrays
IR Radiation Effects
Radiation Discriminating Photodetectors
HYWAYS (Long Wave IR Detectors)
Monolithic Dual Band HGCDTE Arrays
HAVE GAZE
Multi-beam Antenna
Multi-Mode Processing Array
44 Ghz Receiver
60 Ghz Low Noise Amplifier

DERIVATIVE METRIC SUBSYSTEMS:*

ARMY

Modular Decontaminating System (Engine Only) (formerly listed under
MSS under RDT&E)

NAVY

None Listed

MARINE CORPS

None listed

AIR FORCE

None listed

* A metric weapon system (or subsystem) is one for which the contract required the system be designed using the metric system of measurement with or without exceptions being authorized for use of existing nonmetric components or allowing use of nonmetric world standards such as inches for electronics.

A derivative metric weapon system (or subsystem) is one for which the design was derived from an existing metric system, such as a modified version of a foreign weapon system.

Appendix D

Metrication Transition Plans & Activities of Government Agencies (selected maritime related)

NISTIR 4911

~Bf)2-222249

Metric Transition Plans and Activities of Federal Government Agencies

Gary P. Carver

U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Institute of Standards
and Technology
Metric Program
Gaithersburg, MD 20899

Raymond A. O'Brien, Jr.

Metiti-on Project Office
internal Revenue Service
Washington, DC 20224

Byron Nupp

Office of Economics in the
Office of the Secretary, and
Metric Coordinator
Department of Transportation
Washington, DC 20509

August 1992



U.S. DEPARTMENT OF COMMERCE
Barbara Hackman Franklin, Secretary

TECHNOLOGY ADMINISTRATION
Robert M. White, Under Secretary for Technology

NATIONAL INSTITUTE OF STANDARDS
AND TECHNOLOGY
John W. Lyons, Director

NIST-114A (REV. 3-80)	U.S. DEPARTMENT OF COMMERCE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY	PUBLICATION OR REPORT NUMBER NISTIR 4911 PART NUMBER PB92-222249 SEPTEMBER 1992
BIBLIOGRAPHIC DATA SHEET		
4. TITLE AND SUBTITLE METRIC TRANSITION PLANS AND ACTIVITIES OF FEDERAL GOVERNMENT AGENCIES		
5. AUTHOR(S) Gary P. Carver, Byron L. Nupp, Raymond A. O'Brien, Jr.		
6. PERFORMING ORGANIZATION (IF JOINT OR OTHER THAN NIST, SEE INSTRUCTIONS) U.S. DEPARTMENT OF COMMERCE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY GAITHERSBURG, MD 20899		7. CONTRACT/GRANT NUMBER 8. TYPE OF REPORT AND PERIOD COVERED
9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (STREET, CITY, STATE, ZIP) U.S. Department of Commerce National Institute of Standards and Technology Gaithersburg, MD 20899		
10. SUPPLEMENTARY NOTES		
11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.) This report presents an overview of the metric transition planning efforts of federal agencies. It contains summaries of the individual federal agencies' metric transition plans. It includes a set of criteria for evaluating the quality of an agency metric transition plan. Also included is a description of an overall, "aggregate," appraisal that results when the criteria are applied to the entire federal agency planning effort as though it were a single comprehensive plan. This report is intended for use by federal agencies, as well as by any organizations and individuals whose business-related activities are affected by federal agency programs.		
12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS) Metric; metrication; metric policy; metric system; metric transition.		
13. AVAILABILITY <input checked="" type="checkbox"/> UNLIMITED <input type="checkbox"/> FOR OFFICIAL DISTRIBUTION. DO NOT RELEASE TO NATIONAL TECHNICAL INFORMATION SERVICE (NTIS). <input type="checkbox"/> ORDER FROM SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, DC 20402. <input checked="" type="checkbox"/> ORDER FROM NATIONAL TECHNICAL INFORMATION SERVICE (NTIS), SPRINGFIELD, VA 22161.		14. NUMBER OF PRINTED PAGES 112 15. PRICE A06

ELECTRONIC FORM

EXECUTIVE SUMMARY

The modern metric system¹ is now the international standard of measurement. To be competitive in international markets, products must be designed, manufactured, and specified in metric units of measurement.

Certain industries in the United States have not yet converted the quantitative specifications of their products and services to metric units. Except in a few cases where non-metric units are accepted worldwide, this delay imposes a trade barrier to U.S. products, and thus an impediment to increased competitiveness.

The Challenge

The Federal Government is required to begin using the metric system in its business-related activities, except when it is not economically feasible or it is likely to cause U.S. firms significant inefficiencies or loss of world markets. The purpose of this requirement is to help lead the Nation into a more competitive position in global markets. The amended Metric Conversion Act and Executive Order 12770 require the Federal Government to provide leadership by setting an example and by using its leverage and buying power as the largest customer in the United States to catalyze a transition to the metric system by U.S. industry.

The Secretary of Commerce is required to coordinate the Federal Government's transition to the use of metric units. Working through the Interagency Council on Metric Policy, the interagency Metrication Operating Committee, and a number of functional subcommittees, the Secretary must provide the leadership, policy guidance, and evaluation of overall progress necessary to energize the metric transition by Federal Agencies. This report is in support of the Secretary's responsibilities for leadership and coordination of the federal transition to metric usage. On October 1, 1992, as part of her annual assessment of federal metric transition progress for the President, the Secretary will include recommendations for additional measures, including proposed legislation, that will help to achieve the full economic benefits of metric usage.

The Current Evaluation Methodology

Previous evaluations of the metric transition efforts of federal agencies by the General Accounting Office and the Congressional Research Service found limited evidence of progress in planning for use of the metric system and a low level of compliance with the requirements. However, now more than ever before, the evidence is increasingly pointing to significant progress by federal agencies in fulfilling the requirements. This assessment is based upon the current Metric Transition Plans of the federal agencies and upon up-to-date information about the implementation of the plans.

Planning information from the federal agencies was evaluated using a set of criteria organized into three categories: organizational factors, such as authorities and reporting

¹ The modern metric system is known as the International System of Units, which is abbreviated SI and which is interpreted or modified for use in the United States by the Secretary of Commerce (55 FR 52242, December 20, 1990, "Metric System of Measurement Interpretation of the International System of Units for the United States").

responsibilities; content factors, such as programmatic tasks, transition mechanisms, timetables, interactions, and supporting activities; and maturity factors.

The Current Evaluation Results

The current evaluation reveals new and encouraging information about the Federal Government's metric transition. The transition effort is both more complicated and more advanced than may have been apparent. All executive departments have draft, partial, or final Metric Transition Plans. Most major independent agencies have completed their plans.

Overall the plans demonstrate good planning methods, comprehensive scope, acceptance at high levels, participation by all levels, private-sector involvement, and a recognition of the need to incorporate metric usage into regular operations. The plans reflect significant progress in adoption of the metric system of units by federal agencies.

Nevertheless, some plans elicit a number of concerns. Most importantly, a few agencies do not yet have comprehensive Metric Transition Plans. Their plans are only general outlines or they are limited to a few operating units, which do not constitute agency-wide plans. Three deficiencies are common to many of the plans: a lack of a consistent basis for review and revision, a tendency to mix program and support elements in task designations, and a lack of proactive and cooperative involvement with industry and the public.

The Recommendations

It will be beneficial for agencies to review and update their plans as needed and to perform another iteration of their plans in 1993. In addition, as part of this process and since agencies have already scrutinized the measurement sensitivity of their operations and developed initial plans, an interagency review of plans and a greater coordination among agencies can extend the benefits of a shared experience. For example, extraction of a common set of business-related support elements such as procurements, regulations, and grants; interagency review of plans and progress; and coordinated policies for selected actions such as outreach programs, legislative programs, state government coordination, and timing of implementation could help smooth the transition process.

A number of interagency need-driven cooperative activities are ongoing. These include measuring the degree of metrication in U.S. industry, coordinating federal metric construction practices, developing a policy in cooperation with industry on metric size standards for government correspondence and publications, and evaluating metric training materials for use by federal employees. Other need-driven interagency efforts should be encouraged.

The Conclusions

The Federal Government's metric transition program is proceeding in a practical, orderly, and evolutionary way toward the use of metric units in all business-related activities. There is no deadline when some instantaneous and dramatic change to metric usage will occur. Federal agencies are developing and implementing transition plans and cooperating on mutual concerns, and they are working with industry and user groups to establish a realistic schedule for change.

It is evident that the large majority of federal agencies are committed to the metric transition process and have made significant progress. Yet, the range of agency-to-agency variations in the rate of progress is broad. Some of the variations in visible progress result from agency programmatic factors. For example, some agencies are much more involved than others in procurements, grants, regulations, and other business-related activities. Also, some agencies have greater impact on U.S. industry, including the regulation of industry, than others. Furthermore, there is a large variation in the size of agencies. Therefore, it is important in assessing the viability of the federal leadership role in the metric transition to inspect the plans of the major industry-influencing agencies and to avoid simple averages or generalizations about all agencies.

The progress that federal agencies are making to implement metric usage will require some time to reach the point where metric units are used routinely. For example, agencies that have implemented a policy to use metric units on all new projects will not make predominant use of the metric system until such new metric usage becomes a significantly large part of the agency's activity. Budgetary restraint which limits new project initiatives, safety considerations, transition costs, and external factors will all affect the pace of the change.

In addition to needing time for metric policies and plans to be implemented in the federal government, continuing visible top-management commitment to the metric transition and leadership is essential for success. This is also true in state and local governments and in the business community. Leadership is especially needed in critical areas that involve long lead times, such as education, including work-force training.

Clearly the completion of federal metric efforts will take time. In addition, to assure the most beneficial result, it will take the continuing support of Congress and the cooperation and active participation of industry and state and local governments.

Although there are competing national priorities, the U.S. moves further every day along the path to joining the global community in measurement standards. The efforts of federal agencies are moving us more rapidly along that path.

PREFACE

Change-the resistance to it, the fear associated with it, and the challenge represented by it-is a popular sociological and psychological subject. There is no doubt that change is usually difficult. Clearly this has been true of the U.S. change to the use of the metric system of units.

However, there is another aspect to change that is often overlooked: Whatever the need for change, it is when the success of a change is demonstrated that the demand for the change increases.

In the case of changing to use of the metric system, success has been demonstrated in the United States by many individual companies and by certain industries. As a result, there is a demand in other industries for change. This is consistent with the rationale for the change, the need to remove a trade barrier to U.S. products.

Although the need is also present in the domestic consumer sector, the success related to using the metric system has not yet been visibly demonstrated in that sector. Consequently, the public is not yet demanding the change.

The Federal Government's role is to provide leadership and encouragement to help U.S. industry make the transition. To succeed in that role, federal departments and agencies are making the transition themselves. Not surprisingly, they are finding that, in some areas, what may seem like a simple and direct change is, in fact, complex and not so straightforward.

For example, the government's primary focus, as required by the Metric Transition Act, is on procurements, grants, and business related activities. Procurements are especially complex because there are a number of requirements that affect the procurement process, including cost, country of origin, small and minority business considerations, and functional specifications. Meeting these requirements can sometimes conflict with achieving the goal of procuring products and services to metric specifications.

In addition, even with a good plan to implement the use of metric units for procurements, the implementation depends on the initiative of many individuals at all levels of the government as well as the cooperation of their non-federal-agency customers. It may also require coordination, guidance, and possibly federal and business employee training. Since the planning and implementation are the responsibility of the individual agencies, each agency must deal with these details in its unique environment.

In previous years, there seemed to be a reluctance among agencies to be first to convert to using metric units. At one meeting, someone said they would like to be a settler in the new metric territory, but not a pioneer. Apparently, settlers peacefully build homes and plant crops; while pioneers are viewed as transgressors, and may be treated accordingly. Pioneering is more difficult than participating in a communal environment. This would also hold true in industry, since it is easier for individual companies to participate in an industry-wide transition than in a pioneering effort.

Whether the avoidance of being first is due to a fear of taking risks or to a desire to stick with the majority, there is a benefit from this phenomenon. We are seeing the benefit now. In many agencies the desire not to be first is changing into a desire not to be last. Now

that the momentum is accelerating, the same forces that fostered an aversion to being first are resurfacing and are causing agencies to avoid being last.

Another phenomenon that will soon help to accelerate the metric transition in government and industry is the production in some industries of metric products that are identified by nominal inch-pound units. One example is computer industry hardware, including floppy disks. They are produced to metric specifications, even though the common dimensions cited in this country for the same products are inches. When industry perceives that the metric transition has become more acceptable to the public, these and other products will be more accurately identified by their correct units of measure. Consequently, it will appear that the metric transition is accelerating.

Many companies have policies in place to produce metric products on demand. In some cases these metric products are not truly metric because they may be only non-metric products cut to dimensions that approximate their metric-sized counterparts. However, in most cases companies are aware of international standards and are poised to design and manufacture products completely in round, or rational, metric units. As the demand for and willingness to accept metric products increases, partly due to the encouragement of the Federal Government, this phenomenon will also help accelerate the metric transition in this country.

The information in this report demonstrates that change is occurring-and that it is accelerating.

Gary P. Carver
Raymond A. O'Brien, Jr.
Byron Nupp

INTRODUCTION

The leadership and coordination responsibilities of the Department of Commerce in the federal agency metric transition include assessing the progress made by other federal agencies in implementing the use of metric units in their programs. The purpose of such an assessment is to provide feedback and guidance to the agencies that will be beneficial and will help improve their rate of metric transition progress. The primary purpose of this report is to disseminate an overview of the status of the federal agency metric transition that was developed from the assessments.

The second purpose of this report is to provide information to federal departments and agencies that will help them to evaluate, compare, and coordinate their metric transition planning activities.

State and local government agencies, U.S. companies, and the public can benefit also from information on the federal government's metric transition effort. Organizations and individuals in each of these environments will, if they have not already, be making decisions relating to the use of metric units in their business-related activities. The rate at which the federal government implements the use of metric units in its procurements, grants, and other business-related activities directly affects activities in these other sectors of our Nation. Therefore, providing useful information to non-federal agency organizations and individuals is a third purpose of this report.

This report presents an overview of the metric transition planning efforts of federal agencies. It contains summaries of the federal agencies' metric transition plans. It includes an set of criteria for evaluating the quality of an agency metric transition plan. Also included is a description of an overall, "aggregate," appraisal that results when the criteria are applied to the entire federal agency planning effort as though it were a single comprehensive plan. This report is intended for use by federal agencies, as well as by any organizations and individuals whose business-related activities are affected by federal agency programs.

The Federal Government's Metric Transition

A Public Law [1] and an Executive Order [2] provide both the rationale and the mandate for a transition to the use of metric units. The rationale is the need to remove a trade barrier to U.S. products, as well as to improve our competitive edge, since the modern metric system is now the international standard of measurement. The metric system, for purposes of international trade, is more than just the International System of Units (SI). In international trade, "metric system" refers to the use of product standards and preferred sizes that are accepted by industries and governments throughout the world. Accordingly, it is essential that "world class products" be built to metric specifications to be competitive in the international marketplace.

The mandate in the Law and Executive Order calls for the Federal Government to use the metric system in its business-related activities, unless it is not economically feasible or is likely to cause significant inefficiencies or loss of world markets to U.S. firms. It is intended that the Federal Government help lead the Nation into a position where it can more competitively participate in global markets. The Federal Government can do this by setting an example and by using its leverage and buying power to catalyze a transition to the metric system by U.S. industry. The Federal Government is the largest customer of

U.S. industry. By offering to buy metric products and services, government can help industry make the transition to the use of metric units of measurement. In addition, by requesting metric products, the government can demonstrate its commitment to the metric system of measurement for the Nation's businesses.

Coordination of the Federal Government's Metric Transition

The Executive Order designates the Secretary of Commerce as the coordinator of the government transition to the use of metric units. The Department of Commerce has long been concerned with the technical aspects of metric usage through NIST'S role as the Nation's science and engineering laboratory for measurement technology and research on standards. Since its founding in 1901, NIST has played a major role in the evolution of a national measurement system policy by providing the measurements, calibrations, data, and quality assurance that are vital to U.S. commerce and industry. NIST also provides technical support to the National Conference on Weights and Measures, an organization of state, county, and city weights and measures enforcement officials and associated business and consumer representatives.

The Executive Order authorizes the creation of an interagency council and advisory committees, as well as the dissemination of policy guidance for agencies. Therefore, the Interagency Council on Metric Policy (ICMP) was chartered by the Secretary of Commerce. It is chaired by the Under Secretary for Technology and is composed of policy-level officials (assistant secretary or equivalent). They represent the federal departments and agencies in the development and coordination of metric usage policies and programs.

The Metric Program of the National Institute of Standards and Technology is the key element of the Department of Commerce metric transition leadership and coordination effort. The Metric Program helps implement national metric policy through a federal agency metric transition by developing and providing policy, guidance, support, and evaluation of progress to federal agencies. The Metric Program chief chairs the interagency Metrication Operating Committee and its Steering Group. Also, the Metric Program provides information and guidance on metric issues to federal agencies, state and local governments, trade associations, business firms, and the general public.

Interagency Cooperation

A growing number of agencies are cooperating to address common issues and to deal with shared problems. This is especially apparent among agencies whose activities focus on procurement, regulation, and small-business activities.

The Metrication Operating Committee (MOC) is composed of senior-level metric coordinators from the federal agencies. The subcommittees of the MOC address specific topics of interest to several different agencies. These areas include, for example, construction, education, procurement grants, standards, and federal employee training. Many agencies participate in the activities of the subcommittees and benefit from the combined efforts.

The Construction Subcommittee is one of the most active and successful groups. It has attracted participants from private industry and has published a metric-usage guide for commercial construction. The subcommittee's work is funded by participating federal agencies, and its members have visited Canada to explore the Canadian experience.

Recently, the National Institute of Building Sciences, which served as secretariat for the subcommittee, created a Construction Metrication Council to build on the work of the subcommittee and to enable even greater participation by private industry. MOC agencies have accepted the Construction Subcommittee's goal to design all new federal facilities in metric units by January 1, 1994.

Another example of the growing cooperation among federal agencies to meet the mandate to use the metric system is the leadership of the Government Printing Office (GPO) and the Internal Revenue Service (IRS) in exploring a change to metric-sized paper, printed forms, and documents. To examine and discuss the issues, GPO invited other agencies to meet with the staff of the Joint Committee on Printing. The approximately 60 representatives considered the advantages and disadvantages of adopting standard metric paper and binding sizes, compared to continuing use of the current sizes described in metric units. They appointed an ad hoc committee to develop surveys of industry and the federal agencies, as well as a timetable for reporting the results. The federal agency survey has been completed. The possible impacts on the paper and printing industries are being examined; they include transition costs and long-term benefits, document handling, storage, reproduction, information management, and other related activities. The consensus of the participants at the meeting was that potential problems should be identified and a progressive policy and practical timetable be developed with industry's cooperation for the Federal Government's transition to the use of metric-sized paper, forms, and documents. The effort is underway.

In both examples, an important outcome will be that U.S. manufacturers (of construction and building products and of paper products) will be in a better position to export their products.

1992: A Special Year

This year, 1992, is a special year in the implementation of the mandate. The law requires that "each federal agency, by a date certain and to the extent economically feasible by the end of fiscal year 1992, use the metric system of measurement in its procurements, grants, and other business-related activities..." The Executive Order requires that agencies provide to the Secretary of Commerce, by June 30, 1992, "an assessment of agency progress and problems, together with recommendations for steps to assure successful implementation of the Metric Conversion Act." The Executive Order also requires in 1992, as part of the annual report to the President by the Secretary of Commerce, "recommendations which the Secretary may have for additional measures, including proposed legislation, that will help to achieve the full economic benefits of metric usage."

This year is also special because more significant progress is occurring than has occurred in any previous year. This will be viewed as a watershed year in the federal metrication process.

PREVIOUS EVALUATIONS

A 1990 report by the General Accounting Office, METRIC CONVERSION: Plans, Progress, and Problems in the Federal Government, was based upon a survey of federal agencies. [3] The General Accounting Office (GAO) found that planning for metric conversion among the federal agencies was limited. The report noted that schedules, specific target dates, and time frames by which to measure progress were absent in

addition, the report stated the finding that progress toward implementing plans and other activities to address specific transition issues was also limited. As a result of a limited planning and progress, as well as other evidence of a low level of effort, the report concluded that there was reason to "question the federal agencies' commitment to the transition process.

The GAO report singled out the leadership of the Commerce Department as a major concern. At the time, the Under Secretary for Technology, to whom high-level coordination duties were delegated, had not been designated. The GAO recommended that the Secretary of Commerce take steps to respond to the needs by developing guidelines for federal agencies that include specific time frames and a realistic estimate of resources needed for a transition to use of the metric system of units. The Secretary was also advised to fill existing vacancies on the Metrication Operating Committee's functional subcommittees and to make an effort to encourage their effectiveness.

In November of 1991, the Congressional Research Service (CRS) published a report entitled Metric Conversion Activities of Federal Government Agencies in Compliance with P.L. 100-418, Section 5164, Metric Usage. [4] This report included synopses of the 1990 annual metric progress reports and metric transition plans of federal agencies. The findings in this report were that although agencies are demonstrating a greater commitment toward metric usage, many of them are not fully complying with the legislative mandate, and an "across-the-board" transition to the metric system by the end of fiscal year 1992 is not likely.

As did the GAO report, the CRS report referred to the Commerce Department's leadership role and concluded that the Department needed to enhance its effort to meet the requirements of the law.

METHODOLOGY FOR THIS Evaluation

The individual department and agency metric transition plans are the central documents that were used for this evaluation. However, other documentation that involves planning activities and implementation of plans was also included. Furthermore, direct conversations were held with agency metric coordinators to ensure currency of the planning documents and information presented.

The package of planning information was evaluated using a set of criteria that included organizational factors and content factors. In addition, a sense of the "maturity" of the plan was developed.

The organizational factors included the existence and completeness in the plan of the following components:

1. Authority and accountability framework for the planning and implementation processes. The approval by the agency head, the assignment of a metric executive, the tasking of operating unit heads, and the scope of the authorizing instrument are described.
2. Operating unit responsibility and reporting. Designation of operating unit reporting responsibilities, scheduling of reports, channels of downward and

upward communication, provision for problem-solving, and relationships to agency-wide reporting practices are adequately defined.

3. Involvement of personnel throughout the agency. The relation of metric assignments to agency-wide organization and flow of responsibility and communication, the ability of key individuals to reach appropriate staff, and the provision for general staff awareness are adequate.
4. Provision for evaluation and revision. The timing and procedures for updating the plan are described.
5. Arrangements for incorporation of the planned implementations into regular program activities. Metric conversion, when completed in an agency or operating unit of an agency should be a regular part of operations and the work of the staff. Provisions for identifying such a stage, the timing of it, and the authority to implement it are included.

Criteria numbers two and three involve delegation of authority and responsibility throughout the agency. Involvement of all staff, including top officials as well as support staff, is considered an essential ingredient of a successful plan.

The content factors were evaluated on the basis of the inclusion of the following components:

1. Identification of affected programs and activities. Programs are identified in relation to the agency's scope of activities and their measurement sensitivity is indicated.
2. Identification of excluded programs. In accordance with Public Law 100-418, programs are identified where metric usage may be impractical or where metric usage is likely to cause significant inefficiencies or loss of markets to U.S. firms.
3. Provision for exclusion justification. Where an exclusion in accordance with Public Law 100-418 is claimed, a suitable justification is provided, including the methods of analysis that were used. The Executive Order requires exclusions to be approved by the agency head.
4. Timetable for program conversion. The timetable for currently planned transitions, the process for establishing future transition dates, and the steps for converting program activities to use of metric units are described. Blanket or overall timing patterns are avoided; timing provisions are related to the program content.
5. Federal-state-local government consultations and agreements. Interactions with other federal agencies and with state and local governments that involve the transition of program activities to metric usage are described. This includes interrelationships with legislative and regulatory activities. Suitable participation of state and local officials through meetings, conferences, and notices should be provided.
6. International standards affected by metric conversion. Any impact of national or international standards activities on program metric transition activities, or, conversely, any impact of program metric transition activities on standards activities, are described. The conference report on Public Law 100-418 states the intent of Congress not to force metric conversion in areas where worldwide standards usage and practices adhere to non-metric standards.
7. Private sector consultations. The impact of the metric transition of federal programs on private sector organizations and individuals is described. This

includes those who supply products and services to the government, are subject to regulations, receive grants and assistance, and provide education and training. Where official notices, awareness campaigns or other efforts to minimize the impact are required, they are described in detail.

8. Federal employee training. The extent and type of training required are identified.
9. Private sector education. Federal programs that affect the industry and the public, such as regulations that have measurement sensitivity, may require provision of awareness campaigns or training. These needs and solutions are adequately described.
10. Safety impacts. Provision for safety impact studies and assurance of follow-on action are described.
11. Special planning studies. Where long term approaches to complex issues are involved, research and consultation may be required. Such issues are anticipated and contingencies are provided for, should new problems arise.
12. information resource management. The relationships among existing data systems and computer systems are identified and provision is allowed for the inclusion of any new metric demands on the systems.
13. Legislative programs. Legislative, regulatory, or legal barriers to metric implementation are identified. Where practicable, measures for the removal of such obstacles are described.
14. Budgetary Impacts. Where metric conversions cannot be accommodated into existing program budgets, or are not incidental to normal operations, these are noted. Provision is made for increased budgetary needs.
15. Review and revision of the plan. The mechanisms and procedures for appropriate reevaluation and modification of the plan are described.

The maturity factors reflect the conditions for metric conversion in the agency. There were five levels of maturity that were used to judge the degree of maturity: (1) no awareness, (2) beginning awareness, (3) organized preparation, (4) operational implementation, and (5) program incorporation.

AGGREGATE EVALUATION

There are thirty-nine member agencies of the Interagency Council on Metric Policy. Of the fourteen cabinet-level departments, nine have Secretary-approved Metric Transition Plans, three others have plans in "draft" form, and one had a notice in the Federal Register that described its proposed plan and requested comments. Among the twenty-five member agencies that are not departments, nineteen have approved plans and one published a Federal Register notice that describes its metric transition intentions. Several other agencies are participating in a variety of ways in the federal metric transition and the ICMP; however, their plans and policies are not included in this evaluation.

Some Preliminary Qualifications

In the rest of this section, the word "agency" refers to one of the thirty-nine ICMP members. No distinction is made between cabinet-level departments and independent agencies.

Certain agencies have more impact on industry and the public than other agencies through their regulatory, procurement, or *other* business-related activities, or through their size or budgetary resources. However, no measure of agencies' impacts on industry, or of the economic status of affected industries, was attempted, and no mathematical or other weighting was assigned to any agency for evaluative purposes.

Although the plans are important indicators of intents and probable actions, what really counts is what is actually happening as a result of the actions of the agencies. In many cases, progress is occurring through the policies expressed in the plans instead of as a result of the implementation of specific planned activities. (Frequently this occurs in agencies where plans are designed to distribute responsibility and to empower staff at lower levels in the organization.) Some agencies whose plans appear to be merely general administrative regulations have progressed quite far, and are participating actively in interagency efforts. Other agencies are involved in leadership roles in the overall federal metric transition, but these roles are not reflected in their plans. Collectively, the plans are weak in leadership and coordination activities because they were developed individually by the agencies. A number of cooperative efforts among the agencies are currently ongoing; the individual plans do not contain planning information on these efforts.

It can be concluded, therefore, that the actual state of metric transition planning and implementation at some agencies is not apparent from their plans. (This is evident also in the "significant developments" that are described at the end of the summaries of the plans in the Appendix.) As a result, the actual state of metric transition efforts in the Federal Government is not evident from the agencies' plans.

Estimates of Quality and Completeness

The criteria are grouped into "organizational" and "content" factors.

Organizational Factors. The overwhelming majority of the plans assign responsibility and coordination of the agency metric transition process to a high-level official and appropriately place responsibility on the constituent organizational elements to provide more detailed plans as well as reports. All plans designate a metric executive, as required by the Executive Order. Some of the plans centralize authority in one top-level official in the agency while others delegate authority to operating units. (In a few of the latter cases, one or more of the operating units have developed outstanding plans.) In the best plans, the top levels of the agencies not only offer authority and policy guidance, but also direct administrative support in critical areas such as procurement and grants management.

Although the designation of reporting responsibilities is often clear, the schedules of reports and channels of communications are not as clear. The lack of clear channels of communication affects the flow of information on metric issues and, as a result, leads to uncertainty about the procedures and consultations necessary to deal with decisions related to metric changes. While this may not matter in the case of a plan where, for example, the policy is that all new measurement-sensitive activities will use metric units whenever possible, undefined communication paths are an impediment to change where carrying out policy involves significant use of judgement.

The lack of well-defined channels of communication is also an impediment to change where decisions are impacted by other priorities, such as cost. When there are competing priorities, not knowing who has the authority or who must be consulted to make the final

decision may result in avoidance of any new actions. It is interesting to note that the procedures and communications necessary to exempt an activity or program from required metric specifications are typically well defined, while the procedures for evaluating and updating the plan tend to be vague or absent.

In some agencies' plans, the responsibilities and interactions among officials responsible for carrying out the metric transition planning and reporting activities are not directly related to other functional operations at agencies. This inhibits the incorporation of planned changes into regular program activities. Furthermore, unless the plan contains specific efforts and timetables for completing them, the weak relationship among metric transition activities and other functional activities may inhibit the progress of the metric transition. The relative isolation of the metric-related responsibilities and authorities in many agencies is not conducive to incorporating the use of metric measures into ongoing functional operations.

Generally, agencies' plans can be rated "good" in their organizational factors, although a minority are incomplete in some of the required factors, especially the provisions for plan evaluation and revision and for incorporation of the plan into regular program activities. Plans that are most complete in meeting the organizational criteria provide top-level direction yet delegate responsibility of carrying out the policy to lower, more programmatic, levels.

Content Factors. The overall quality of the plans is good. They are well-written, follow good planning practices, and promise some significant achievements. However, the plan contents could be improved by better definition of the programs and activities that are to be addressed and by clearer statements of the desired accomplishments. There is a need for more specific and more detailed descriptions of new or changed functional activities as a result of metrication. The formulation of policy into substantive tasks with well-defined durations and sequences of steps is weak in some plans. Few of the plans contain, or require in the planning process, quantitative information.

The identification of affected programs and activities is good. They are mainly the business-related activities identified in the Executive Order. The most significant defect in many plans is simply the omission of important agency programmatic activities that are measurement-sensitive.

The identification of excluded programs and the provisions for justifying the exclusion of programs are good. Appropriately, excluded programs tend to be large, ongoing programs having existing non-metric hardware, programs where safety factors are paramount, and programs where it is believed that the U.S. industry is non-metric. Few of the plans require suitable analytic procedures for determining practicality, significant inefficiencies, or loss of U.S. markets.

Timetables for converting programs to the use of metric units are usually specific and appropriate to the program content.

Interactions with other federal agencies and with state and local government organizations are seldom mentioned in the plans. For many agencies, such interactions are not normal components of their programs and may not need to be discussed in their plans. However, some agencies' activities have a large impact on state and local government programs. In

a number of cases, such agencies have also neglected to plan for interactions with the states and localities.

It is ironic that the modern metric system of units is an international standard; yet, most agency plans omit mention of international standards. Many agencies design parts, buy equipment, or utilize measurement-sensitive information that is dependent upon international standards. However, those agencies that have operating units that are involved directly in standards-related activities do take appropriate account of the interaction between their activities and the activities of international standards bodies.

The plans are reasonably responsive to the need to cooperate and coordinate transition efforts with customers affected by agency actions. Many agencies have published notices and have participated in activities with representatives from industry and other groups. This especially includes cooperative interactions with suppliers of products and services and, most often, recipients of grants and assistance. Most plans could be improved by the inclusion of conversion methodologies and the consultation with industry on specific metric transition goals. There is a need for more proactive interactions with entire industries, possibly through appropriate industry associations, to evaluate the mutual needs and to plan cooperative approaches for making appropriate changes on an acceptable time scale.

Federal employee training is adequate to good in the plans. Training is easy to do. However, it is not clear whether the training is tutorial, awareness-oriented, technical, or application-specific (such as procurement-specific) in nature. [In addition, it is not evident that agencies have analyzed the type of training needed by employees who must make decisions or take specific actions to implement the intent of the plans.

With a few exceptions, private-sector education is not applicable to certain agencies and is not addressed by others. This factor tends to be completely missing from agency plans. Although there is no mandate to educate ordinary citizens about the metric system, there is a requirement in the Executive Order to "increase understanding of the metric system of measurement through educational information and guidance and in Government publications." Several, primarily technology-related agencies, have published documents useful in this regard.

Safety impacts are suitably addressed by the appropriate agencies.

Special planning studies are scarce in the plans. Although complex issues are anticipated, sometimes they are anticipated so well and in so much detail that the discussion may appear to be justifying programs as candidates for exception or implying that exceptions might be the rule at this time. Few contingencies are described where complex issues are concerned. Most often in areas recognized to have complexities, the plans present a gradual approach, such as the use of dual units for a period of time. Rarely are alternatives offered, or criteria and dependencies established to decide among them.

In the aggregate, the plans cover a very wide range in quality in their content factors. Fully half of the larger agencies range from adequate to good. Of the rest most of them incompletely address the agency's functional areas and responsibilities. More importantly, several of the plans are outstanding examples of high-quality, thoughtful, and complete approaches to meeting complicated challenges.

Maturity Factors. Not surprisingly, agencies that meet the content criteria completely and with high quality planning methods are further along toward “program incorporation.” Other agencies range from beginning awareness to operational implementation. No agency plan could be considered to reflect “no awareness” of the metric transition task.

Other Considerations

Scrutiny of the federal agency Metric Transition Plans leads to the conclusion that the agencies can do better. Examination of the current actions of the agencies suggests that they will do better.

The strength of the connection between what is in a particular plan and what that agency accomplishes is not always apparent. The provision of authority and responsibility in a plan may or may not translate to active involvement and leadership by responsible officials. A timetable with specific tasks and dates may or may not lead to any efforts or accomplishments. Because some agency activities are easier to convert to metric specifications than others, some plans may not adequately anticipate the difficulty of implementing the planned accomplishments. In many cases, agencies are constrained by factors they cannot control, such as budgets or the actions of industry and the public. Plans are just that-plans.

As a result of such considerations and of the aggregate evaluation of the current plans, it seems that it would be desirable for each agency to revise its plan periodically. This process would include a comparison of planned actions with what the agency is actually accomplishing. It would also take into account what the agencies are accomplishing cooperatively and the progress of the metric transition occurring in industry. One goal would be to incorporate more specific tasks into the plans; such tasks could be based upon the experiences of the agencies in their current efforts.

It is likely that periodically and iteratively revising the plans will result in greater value to the agencies than they could gain from treating their plans as “one-shot” plans, even if those plans were ideal. In any event, since compliance with the law and the Executive Order has been essentially achieved, agencies are ready for the next steps. In the federal agency metric transition planning process, the next steps are reevaluation and revision of the plans.

IN CONCLUSION

The Federal government’s metric transition program is proceeding in a practical, orderly, and evolutionary way toward the use of metric units in all business-related activities. There is no deadline when some instantaneous and dramatic change to metric usage will occur. Federal agencies are developing and implementing transition plans and cooperating on mutual concerns. They are working with industry and user groups to establish a realistic schedule for change. And they are implementing concrete and practical steps to achieve an orderly transition.

There are some new and encouraging signs that come from this current evaluation of the agency metric transition plans. Among the encouraging signs are:

1. Federal agency metric transition plans demonstrate appropriate prioritization and reasonable planning approaches;
2. Comprehensive inclusion of agency programs in the plans is evolving;
3. There is acceptance of metric-transition responsibility by high-level agency officials;
4. Within agencies, operating units are participating to-a significant degree in the metric transition process;
5. There is provision for appropriate public involvement in agency metric transition plans; the plans clearly show a commitment to cooperation with the general public, state and local government organizations, technical associations, and private sector firms and organizations;
6. The plans contain an implicit recognition of the ultimate incorporation of metric usage into regular agency operations; and, most importantly,
7. The plans reflect significant progress in adoption of the metric system of units by federal agencies.

There are also some concerns. The concerns include the following:

1. A few agencies have not developed comprehensive and detailed agency-wide Metric Transition Plans;
2. There is no consistent requirement for review and revision of plans;
3. There is a tendency to mix programmatic tasks and support tasks in the plans;
4. Some agencies' plans reveal a need for technical assistance; and
5. There is a need for more proactive involvement and cooperation with industry.

It is evident that federal agencies are committed to the metric transition process and have progressed significantly. Yet, the range of agency-to-agency variations in the rate of progress is broad. Agency transition planning activities extend from a demonstratively high degree of maturity and effective involvement of agency staff to a low-visibility, administrative-only implementation that may have little effect in its current form.

Some of the variations in visible progress result from agency programmatic factors. For example, some agencies are much more involved than others in procurements, grants, regulations, and other business-related activities. Also, some agencies have greater impact than others on U.S. industry, including the regulation of industry, than others. Furthermore, there is a large variation in the size and resources of agencies. Therefore, it is important in assessing the viability of the federal leadership role in the metric transition to inspect the plans of industry-influencing agencies that have the most impact and to avoid simple averages or generalizations about all agencies.

[It will be beneficial for agencies to review and update their plans as needed and to perform another iteration of their plans in 1993. In addition, as part of this process and since agencies have already scrutinized the measurement sensitivity of their operations and developed initial plans, an interagency review of plans and a greater coordination among agencies can extend the benefits of a shared experience. For example, extraction of a common set of business-related support elements such as procurements, regulations, and grants; inter-agency review of plans and progress; and coordinated policies for selected actions such as outreach programs, legislative programs, state government coordination, and timing of implementations could help smooth the transition process.

A number of interagency need-driven cooperative activities are ongoing. These include measuring the degree of metrication in U.S. industry, coordinating federal metric construction practices, developing a policy in cooperation with industry to make available to the government paper for publications and correspondence in metric sizes at costs equivalent to non-metric sizes, and evaluating commercially available metric training materials for federal employees. At the same time, other need-driven interagency efforts should be encouraged.

The progress that federal agencies are making to implement metric usage will require some time to reach the point where metric units are used routinely. For example, agencies that have implemented a policy to use metric units on all new projects will not make predominant use of the metric system until the new projects become a significantly large part of the agency's total activity. Budgetary restraint which limits new project initiatives, safety considerations, transition costs, and external factors will all affect the pace of the change.

For example, in construction, until a large fraction of old facilities are replaced with new facilities, or are renovated extensively, almost all government facilities, as well as major equipment will still be described in non-metric units. The use of metric units to describe existing items, however, may be an option, but there will be situations (for example, for safety) where this is not desirable or acceptable.

In addition to needing time for metric policies and plans to be implemented in the federal government, a continuing, visible, top-management commitment to the metric transition and leadership is essential for success. This is also true in state and local governments and in the business community. Leadership is especially needed in critical areas that involve long lead times, such as education, including work-force training.

Clearly the completion of federal metric conversion will take time. In addition, to assure the most beneficial result, it will take the continuing support of Congress and the cooperation and active participation of industry and state and local governments.

Although there are competing national priorities, every day the U.S. moves further along the path to joining the global community in measurement standards. The efforts of federal agencies are moving us more rapidly along that path.

REFERENCES

1. Metric Conversion Act of 1975 (Public Law 94-168, 89 Stat. 1007; 15 U.S.C. 205 et seq. as amended by section 5164 of the Omnibus Trade and Competitiveness Act of 1988, Public Law 100-418).
2. Executive Order 12770 of July 25, 1991, "Metric Usage in Federal Government Programs," (56 FR 35801, July 29, 1991).
3. "METRIC CONVERSION: Plans, Progress, and Problems in the Federal Government," General Accounting Office Report RCED-90-131 (March 1990).
4. "Metric Conversion Activities of Federal Government Agencies in Compliance with P.L. 100-418, Section 5164, Metric Usage," Congressional Research Service (November 1991). (Available from the U.S. Government Printing Office, Superintendent of Documents, Congressional Sales Office, Washington, DC 20402.)
5. McCracken, James B., and Carver, Gary P., *Recommended Agency Procedures for Implementing Federal Metric Policy*, NIST IR 4855 (May 1992).

APPENDIX 1. SUMMARIES OF AGENCY PLANS AND ACTIVITIES

The summaries are organized into the following sections:

1. Directives. A description of agency metric program directives, such as administrative manual additions, administrative orders, notices, memorandums, and guidelines.
2. Responsibilities. Formal designations of the Metric Executive, assignments for operating offices, and duties of metric committees, task forces, or other focussed groups.
3. Reporting Requirements. The coordinating mechanism for the collection and dissemination of metric information to ensure timely and comprehensive oversight and reporting.
4. Exceptions to metric usage. The processes that have been defined and implemented to ensure a high-level review of exceptions, exemptions, or waivers to metric usage.
5. Transition efforts. The organization, tasks, events, and transition schedules.
6. Significant developments. A few examples of current activities to implement the plan.

The significant developments are the accomplishments, documented progress, and upcoming initiatives that could significantly affect the metric transition. Often, information on significant developments was obtained through direct contact with representatives of the agencies.

DEPARTMENT OF AGRICULTURE (USDA)

The Department of Agriculture has a wide variety of programs that involve farming, domestic and foreign trade, conservation, and research and extension services. The Department's research and education oriented programs are favorable areas for the adoption of the metric system. Potential problems and barriers include the great variety and numbers of activities and the diversity of interests affected by those activities. Two important agencies in the Department, the Soil Conservation Service and the Forest Service, are involved in engineering and mapping to a degree not found in other agricultural programs.

1. Directive

The Secretary of Agriculture signed Departmental Regulation 1020, "Department of Agriculture Metric Program" on May 26, 1992.

2. Responsibilities

a) Metric Executive. The Regulation stipulates that the Assistant Secretary for Administration (ASA) will be responsible for the overall policy, management and coordination of Agriculture's metrication program. In addition, a Metric Coordinator is to be designated who will serve as the Department's focal point and liaison with the other governmental and non-governmental metric organizations.

Pages 22-31 are not included in this appendix.
They are irrelevant to the report's subject.

(o) **NIST** sponsored the National Conference on Weights and Measures that with the National Council on State Metrication hosted a forum on the metric amendments to the Federal Fair Packaging and Labeling Act signed into law by the President on February 14, 1992.

DEPARTMENT OF DEFENSE (DOD)

Department of Defense (DOD) programs for national defense are mobilization planning, maintenance of forces and combat organizations, training and military education, weapons systems development, military planning, and alliance maintenance. These programs provide a favorable basis for metric conversion due to their international significance and the heavy dependence of the services on research and development and training and education. In addition to its responsibilities for national defense, the DOD is involved in non-defense industries through the civil *works* programs of the Corps of Engineers.

The DOD metric transition program focuses on two areas: (1) the development and operation of new weapons systems, including ancillary materiel, in metric units, and (2) the procurement, in metric units, of numerous items for the supply of a complex military establishment.

1. Directive

The Department of Defense (DOD) issued DOD Instruction 5000.2, Part 6, Section M, Use of the Metric System, on February 23, 1991. It requires metric standards to be used in all DOD activities, including all elements of defense systems requiring new designs.

2. Responsibilities

a) Metric Executive. The Assistant Secretary of Defense for Production and Logistics is designated the Metric Executive.

b) Milestone Decision Authorities. The Milestone Decision Authority (MDA) is the official responsible for approving any waiver requests not to use the metric system. The MDA is the individual designated in accordance with DOD criteria to approve entry of an acquisition program into the next phase. For major defense acquisition programs, the Under Secretary of Defense (Acquisition) or the DOD Component Head (or, when delegated, the Component Acquisition Executive) is the authority. For major systems, the authority can be delegated no lower than the DOD Component Acquisition Executive. For all other programs, the DOD Component Acquisition Executive may delegate MDA to the lowest level deemed appropriate.

c) Defense Metric Transition Management Group (DMTMG). The DMTMG is the group within the Office of the Assistant Secretary of Defense (Production and Logistics) which serves as the Action Office for managing and coordinating the overall DOD metric transition effort. The DOD Metric Coordinator is in this Office

d) Metrication Steering Group (MSG). The MSG, chaired by the DOD Metric Coordinator, has representatives from the DOD Components. The MSG addresses metrication issues and develops recommendations.

e) Office of Primary Responsibility (OPR). The OPR is the designated office responsible for each Task under the DOD Metric Transition Plan. Each OPR prepares and maintains a Task Plan detailing specific efforts, approaches to preparing any required long-term plans, initiation and completion of milestones, and team membership.

h) Office of Collateral Responsibility (OCR). The OCR is from a DOD component other than the one with the OPR having adequate authority and expertise for needed actions to support the OPRs.

3. Reporting

The DMTMG develops an annual report of metric activities during the past fiscal year for submission to the under Secretary of Defense for Acquisition USD(A) by January 15 of each year. The report is based on reports submitted by each of the member DOD components. The component reports describe major accomplishments, recommendations, metric standardization documents prepared, and significant metric systems or equipment initially developed or acquired.

4. Exceptions to Metric Usage

The metric system will be used in all DOD activities, including all those elements of defense systems requiring new design. However, MDAs may grant waivers on a case-by-case basis if the use of the metric system is not in the best interest of the DOD.

The measurement units in which a system was originally designed will be retained for the life of the system, unless the procuring activity determines it is more advantageous to convert to the metric system. During the transition phase, use of hybrid metric and inch-pound designs may be necessary and are acceptable.

Items of commercial design will be specified in metric units when economically available and technically adequate, or when otherwise determined by the procuring activity to be in the best interest of DOD. Bulk materials will be specified and accepted in metric units, unless being required for use in material designed in inch-pound units.

a) The **Army** is approaching the decision point as to whether it will be seeking waivers for three systems:

All Terrain Lifter Articulated System (ATLAS)
25-ton All Terrain Crane
Advance Aviation Forward Area Fueling

b) **Except for the following, all Navy Pre-Milestone I programs use the metric system of measurement.** Waivers have been approved by the cognizant approval authorities for these systems acquisitions programs:

T-AGS 45, Oceanographic Research Ship
AN/BSY-2 Submarine Combat System

Requests for waivers are currently in process for the following acquisition programs:

Strategic Sealift Ship
Amphibious Warfare Ship

c) Within the Air Force, no Pre-Milestone I waivers have been submitted.

5. Transition Efforts

DOD is revising its January 1989 Metric Transition Plan to bring it up to date, add more detail, modify tasks, and incorporate new goals. The revised plan should be approved during fiscal year 1993.

There are three major parts to DOD's Metric Transition Plan strategy:

a) Implementation of Metric Units in New Designs. Since 1987, the DOD policy has required use of the metric system in all elements of new systems requiring new design unless a waiver is obtained. DOD is establishing procedures to systematically include metric in their programs reviews. Metric as well as other policy requirements will be reviewed during Defense Acquisition Board reviews (for major systems) and program reviews (for less-than-major systems).

b) Facilitation of Metric in "Buy Commercial" Areas. The second approach is to buy commercial products where significant industry metric transition is planned. In this area, the DOD role is to facilitate industry transition by removing barriers, and giving appropriate preference to acquisition in metric. Examples include the automotive and construction equipment industries. However, DOD will not attempt to force metrication where it would not be economically feasible to do so. Thus, DOD will continue to operate in the inch-pound system in commercial areas where significant industry metric transition is not underway.

c) Implementation of the Task Plans. The third approach is to effect transition in several cross-cutting areas of importance to the DOD that cannot be addressed by the other two approaches. These areas are addressed in seven active task plans and four Task Groups maintained on a monitoring/standby basis.

The following is a description of the active task plan objectives. included in the revised plan are tasks that are in a standby or monitoring status. They are logistics, food, clothing and textiles, and health.

Operations, Safety, and Interoperability. This task identifies opportunities to use the metric system to enhance capabilities and interoperability, develop the interface with other agencies and the private sector to resolve safety issues, evaluate the use of differing measurement systems in operations and related instructions, and develop and implement a phased-conversion plan. It also establishes a central activity to coordinate and integrate military transition efforts related to military operations, safety, and interoperability.

Education and Training. This task involves the identifying and addressing the need for development and implementation of a common metric education program. It considers minimum education requirements for use during basis training and commissioning programs, the feasibility of the Services jointly developing metric training modules to use

when instructing operations and support personnel, and guidance for including metric proficiency requirements in job standards.

Specifications and Standards. This task entails the development of a Master List of needed metric and non-measurement sensitive documents, emphasizing documents needed in the development phase. It includes establishment of a joint program with industry and non-government standards organizations to expedite the development and coordination of the documents.

Construction. This task establishes a joint metric transition planning group responsible for developing and implementing plans in coordination with appropriate industry associations (construction, architecture, building materials and supplies, etc.). It also identifies bulk materials that can and should be procured in metric quantities, develops a phased schedule for transition, and determines the feasibility of requiring metric dimensions on all overseas military construction projects awarded to U.S. firms.

Electronics. This task addresses development of new military documentation used in specifying electronic components (general specifications, detail specifications, specification sheets, standard military drawings, commercial item descriptions, etc.) by using the metric system of measurement. The revised plan also applies this procedure for fiber optics. However, the plan applies to only new specifications. Any revisions to existing systems are to be done in the inch-pound system.

Test, Measurement, and Diagnostic Equipment (TMDE). The objective of this task is to establish a joint group of metrology experts and TMDE developers to work with NIST and industry in planning and implementing a metric TMDE and calibration standards program. Included in the plan's task are: inventorying and categorizing existing TMDE by density, metrication rates, and capability assessing the present status of TMDE and conducting market surveys to determine commercial availability and related costs; and assessing the economic feasibility, determining the type of conversion, and establishing priorities and milestones for conversion of TMDE.

Public Affairs. This task encompasses the development and implementation of a comprehensive public relations program and includes development of news releases, articles, and public service radio and television announcements for DOD personnel.

6. Significant Developments

a) Examples of Metric Weapons Systems In the Production Phase:

Army:	M120 - 120-mm MORTAR - Towed Hellfire Missile System Multiple Launch Rocket System Family of Medium Tactical Vehicles
Navy:	MHC 51 C1 Minehunter Ships T-45A Trainer Aircraft Electromagnetic Catapult Aircraft Launching System NATO Sea Sparrow Missile System MK-74 Mod O Versatile Exercise Mine Systems

Marines: MI AI Main Baffle Tank (outside only)
Mobile Electronic Warfare Support System
Advanced Amphibious Assault Vehicle
Combat Excavator

Air Force: Scope Shield

b) Examples of Metric Weapon Systems in the Research, Development, Test, and Evaluation Stage:

Army Ground-Based Surveillance and Tracking System
Ground-Based Radar
Ground-Based interceptor
Future Armored Resupply Vehicle
Fiber Optic Guidance Missile
RAH-66 Comanche Helicopter

Navy: Advanced Rocket System
AN/SQY-I Surface Ship ASW Combat Systems

Air Force: Brilliant Eyes
Advanced Short Range Air-to-Air Missile
Space-Based Interceptor
Space Surveillance and Tracking System
Boost Surveillance and Tracking System

c) Basic military operations for combat, combat support, and combat service support elements in a "wartime" scenario are metric except for aerospace (altitudes) and maritime (depths). Operational plans are in metric units, maneuvers including speed and distance are in metric units, as are consumption factors and fuel rates. Basic loads of fuel and food are also in metric units. Combat engineering operations including mine countermeasure operations, maintaining road networks, bridges, and interplay with allies are all in metric units. Planning for combat service support (anticipated storage space for supplies and transportation planning) and intelligence operations including surveillance and reconnaissance also use metric units. Other metric operations include direct and indirect gunfire support. Metric usage is routine for the serviceman during standard military ground operations. Since all of the services have overseas facilities and are trained and equipped to operate in a combat-like environment, personnel at these facilities contend with metric units daily with no apparent difficulty. Defense mapping is mostly metric now, but the maps and charts that are critical to air or undersea navigation are still in inch-pound units.

d) There were no obvious interoperability problems during the **Desert Shield/Desert Storm** operation involving systems of measurement. A scanning of the "Joint Center for Lessons Learned System" showed no problems that could be attributed to the use, or lack of use, of metric units.

e) The Services are providing **metric training** to personnel who need a working knowledge of the metric system--mostly those operating and maintaining metric-based materiel. Metric training modules are provided in the Program Managers Course at the Defense Systems Management College, and to the specification writers and users at the Specification Management Course.

- f) DOD has developed a **database of metric specifications and standards** needed to support metric weapon systems and equipment. The lists have been provided to the internal standards-preparing activities and to non-Government standards developing groups. A list of federal specifications and standards identified as in need of metric versions has been provided to the General Services Administration. Two specifications and standards workshops have been held: one with the DOD standards community and the other with non-Government standards bodies. DOD issued "Guidelines for Development of Metric Standards and Specifications" in March, 1990.
- g) DOD is actively participating in the **MOC Construction Subcommittee**. it contributed \$84,000 during fiscal year 1991 to develop and implement the Construction Metric implementation Proposal. The Army Corps of Engineers is selecting nine pilot projects to be designed and built to metric standards.
- h) Beginning as soon as possible, but not later than October 1, 1992, all **new military documentation** used in specifying electronic and fiber optic components will use metric units. This includes general specifications, detailed specifications, specification sheets, standard military drawings, and commercial item descriptions.
- i) The **Defense Industrial Supply Center (DISC)** has developed, or will soon complete development of, 125 metric specifications for aerospace components to be adopted as SAE standards. DISC has nearly completed a metric transition plan for fasteners and other commodities under its responsibility. Approximately 1,100 other standards will need a metric counterpart, with 300 already having metric counterparts. DISC also publishes an annual status report on the development of some 800 needed metric standards and specifications.
- j) The Services have completed a **joint study plan** and have identified the number of test, measurement and diagnostic equipment (TMDE) items, metric transition rates, and associated metric transition costs.
- k) The DOD **Metric Transition Public Affairs Charter** has been approved. The American Forces information Service has established a FY '92 program of developing metric articles, posters, and radio and television service announcements.
- i) Virtually all DOD **grants programs** are conducted using metric standards due to their scientific and technical nature.

DEPARTMENT OF EDUCATION

The Department of Education's metric transition plan is in draft form.

1. Directive

The Department of Education metric policy directive is awaiting senior officer review and approval for publication in the *Federal Register* for a public comment period.

Pages 39-58 are not included in this appendix.
They are irrelevant to the report's subject.

been tasked to identify any effect metric conversion has on small business and to coordinate problems in this area with the Small Business Administration.

e) **Embassy Property Acquisitions.** The bulk of the purchases made at diplomatic missions are made from foreign vendors and manufacturers whose business practices require the use of metric measurements.

DEPARTMENT OF TRANSPORTATION (DOT)

Transportation programs in the Department of Transportation perform three functions: provide grants (mostly construction) to State and local governments, regulate the safety of all types of transportation, and perform direct services to the transportation sector, such as air traffic control and waterway navigation assistance. Nine separate agencies administer these activities covering land, sea, and air transportation.

The programs in the Department are measurement sensitive, including engineering specifications for construction, material standards and practices for safety regulations, and operating material and procedures for Department-operated systems. There are two major activities that may not be converted in the immediate future: (1) air traffic control and aircraft standards, in which worldwide usage is based upon U.S. standards and practices, and (2) material standards in railroad safety regulation, which are an established and well understood system of standards that are isolated in large part from world commerce and interchange, at least for now. All other programs are covered in the Department's plan.

Generally, transportation programs involve well-established technical systems and technical staff who are familiar with measurement standards and their conversion to metric units. These factors can facilitate metric planning and conversion. A difficulty arises from the co-existence of many diverse systems of standards and specifications governing all modes of transportation. Also, the Department's programs impact the large number of State and local governments and transportation-related private-sector organizations.

The metric plan of the Department consists of the nine operating agency plans. These plans were guided by a metric order that states a detailed policy and administrative framework and a set of guidelines. The Department as a whole is now in the process of implementing its conversion plans.

1. Directive

The Department of Transportation issued internal directive as Order DOT 1020.1 ID "Department of Transportation Transition to the Metric System." The Order was supplemented by Departmental "Metric Conversion Planning Guidelines."

2. Responsibilities

a) **Metric Executive.** The Assistant Secretary for Policy and international Affairs is designated as the DOT Metric Executive and is charged with reviewing all actions associated with DOT's transition to the metric-system.

b) Heads of Operating Administrations. Heads of operating administrations prepare and recommend to the Secretary metric conversion plans for the administration, and upon approval are responsible for implementation.

c) Metric Coordinating Committee. The DOT Metric Coordinating Committee consists of a representative of each operating administration and Secretarial office. It coordinates metric activities in DOT and provides technical advice concerning metric plans and their revision.

d) Technical Review Subcommittee. The Technical Review Subcommittee assists in the review and iteration of the metric conversion plans and advises the Metric Coordinating Committee on the plans.

3. Reporting

DOT Order 1020.1D specifies that metric conversion plans will be approved by the cognizant administration or office director. In addition, each administration metric coordinator forwards to the Assistant Secretary for Policy and International Affairs written summaries of progress on the completion of the plans and discussion of problems encountered.

4. Exceptions to Metric Usage

DOT Order 1010.1D, Attachment 1, "Guidelines for Metric Usage," calls for plans to identify excluded programs and provide a special analysis justifying those exclusions. The analysis is to be based on quantitative information and contain suitable analytical procedures for determining practicality, significant inefficiencies or loss of markets to U.S. firms.

5. Metric Transition Plans

DOT has delegated the development of specific metric transition plans to its operating administrations. Highlights of the individual plans follow

a) Federal Aviation Administration (FAA). The FAA regulates U.S. aviation safety, certifies the airworthiness and safety of aircraft flying in the United States, operates the air traffic control system, and provides grants in aid to state and local airports. The metric conversion plan recognizes that international air traffic control is guided by the policies of the International Civil Aviation Authority (ICAO) which specifies the use of inch-pound units for altitude, distance, speed, and weight. This world-standard use of non-metric units is specifically exempted from the Metric Conversion Act in the Conference Committee report on the P.L. 100-418, section 5164 amendments to the Act. Metric issues are a concern in the following elements of the FAA program:

Transition Management. The goal is to establish the management framework for carrying out a program by which U.S. airports and airport equipment will be planned, designed, constructed, and installed utilizing the metric system of measurement.

Airport Standards and Advisory Standards. FAA intends to revise its advisory circulars (150 series) to provide metric units as the primary unit of measure. These circulars contain FAA airport planning, design,

construction, and equipment standards, specifications, and technical information.

Airport Layout Plans. FAA plans to have all dimensions on layout plans for existing and planned runways and facilities within airport property boundaries in metric units.

Contract Drawings and Specifications. This will require all airport sponsors and their consultants to construct airport facilities and procure equipment with specifications that utilize metric units.

Education and Training. The development and implementation of a comprehensive metric education program that meets the needs of all FAA employees is required.

b) Federal Highway Administration (FHWA). The FHWA plan is an aggregation of the individual Metric Work Plans developed by the various FHWA headquarters offices for their program elements. Plan implementation is expected to be completed by Fiscal Year 1997.

In carrying out most of its metric responsibilities, the FHWA will be affected by its administrative and consultative arrangements with state highway organizations through the American Association of State Highway and Transportation Officials (AASHTO). In other cases, the FHWA will consult with other federal agencies such as the Departments of Agriculture and Interior on construction specifications for national forest, public land, and national park highways. The regulation of motor carrier safety will follow standard administrative procedures of notice, hearings, fact finding, and public announcement. The metrication effort is divided among the following program elements:

Engineering. Geotechnical design guidelines; hydraulic design guidelines; bridge specifications; national bridge inventory; bridge replacement and rehabilitation program; standard bridge plans; bridge inspectors training manual; highway geometric design standards; construction reports, cost estimates and data pavement design standards; material sampling and testing standards; construction specifications; construction and maintenance.

Environment and Planning. Highway noise manuals; directives and manuals; environmental impact statement manual; seminar material and reports; computer programs for the highway performance monitoring system; computer programs for the national bridge inventory.

Rights-of-Way. States' right-of-way manuals; right-of-way plans; appraisal, acquisition, and relocation standards; highway beautification program standards and guidelines.

Highway Safety and Traffic Operations. Traffic signals and communications equipment; high capacity manual; highway safety program manuals and statistical reports; American Association of State Highway and Transportation Officials (AASHTO) roadway lighting standards; national maximum speed limit; traffic control devices; highway sign standards.

Technology Applications. Projects studies, programs, papers, and articles; procurement of equipment manuals, reports, and computer programs; public awareness activities:

Federal Lands Highway. Construction specifications; defense access roads; manuals, guides, and standards; computer programs; procurement of equipment and supplies; procurement of construction projects.

Motor Carrier. Commercial motor vehicle regulations; reports; motor carrier management information system; motor carrier safety assistance program; size and weight.

Offices of Policy. Highway statistics data collection and compilation; manual for highway statistics; computer program updates; seminar material; legislative change development; research and development staff studies and contract studies; requests for proposals for contracts; testing apparatus; trust fund studies; publications; offices of administration; personnel and training; management systems; contracts and procurement; fiscal services.

c) Federal Railroad Administration (FRA). Highlights of the **FRA** metric transition plan include:

National Magnetic Levitation (Maglev) initiative. FRA requires metric units as the primary units of measurement in solicitations for this initiative. In addition, language requiring metric units will be inserted into Maglev contract deliverables.

Research and Development FRA will require metric units as the primary method of measurement in all new solicitations for analytical studies and for hardware development. This will include the Transportation Test Center (ITC) and the Transportation System Center (TSC).

Safety Program. FRA is determining the feasibility of requiring metric-only in its regulations for the safe operation of freight and passenger trains. If determined to be impractical, FRA would make recommendations for exclusion from the purview of the metric legislation.

Local Rail Freight Assistance Program (LRFA). The LRFA program deals with federal grants to fund the operation of local freight assistance. It establishes procedural requirements that must be adhered to by state agencies seeking grants for the acquisition of rail lines, track rehabilitation, and rail facility construction. The FRA will be analyzing the regulations to determine if exclusion from metric usage is warranted.

Title V Loan Guarantee Program. FRA will analyze the feasibility of requiring the use of the metric system in its regulations for guaranteeing loans to the freight railroads. The loan guarantees are for supporting freight car and locomotive rehabilitation programs and track upgrading projects.

National Railroad Passenger Corporation (Amtrak). The objective of this task is to determine if the metric system should be used in Amtrak's procurements that are funded by FRA grants.

d) Maritime Administration (MARAD). The MARAD plan consists of a combination of the program element plans prepared by the individual MARAD offices. The plan element descriptions and objectives are:

NATO Mobilization Planning. This element involves the preparation of civil plans for NATO merchant shipping during war periods. The NATO Sealift Ship List and DSA Vessel Standby Inventory will be maintained in the metric system.

Maritime Aids--Ship Subsidy Programs. This goal is to perform metric conversion of measurement characteristics in Ship Financing, Construction Reserve Fund, Capital Construction Fund, Construction Differential Fund, and Operating Differential Fund applications and related publications. It also includes the conversion of all other Maritime Aids publications such as the Financial Report Form MA-1 72, and vessel and trade publications.

Shipbuilding. This element involves the conversion to the metric system in four sub-areas: Data collection and dissemination; development of published guidelines; assistance for building ships; procurement of new ships and conversion work.

Ship Operations. This program area involves metric conversion for the following sub-areas: ship repair; ship activation and deactivation; ship operations; ship-related services; ship acquisition.

Market Development. Two statistical databases under the Office of Market Development use the metric System: National Cargo Shipping Analysis System (NCSAS) and Ocean Freight Differential System (OFD).

Port Development. All contractual studies on improved port planning, productivity enhancement, and facilitation of commerce will be published using only metric units; the Maritime Statistical Information System will be reviewed for metric usage.

Research and Development. Beginning in 1992, all research reports will be published using both inch-pound and S1 units; by 1997, all research reports will be published in only metric units.

U.S. Merchant Marine Academy. In the areas of math and sciences, and especially in physics and chemistry, all students will have instruction in and be familiar with the metric system standards to the extent necessary for success in those areas. Because at this time the Accreditation Board for Engineering and Technology (ABET) requires that all instruction in the engineering area be conducted using the dual measurement system, textbooks discuss issues and contain problem sets involving both inch-pound and metric dimensions. Since an increasing number of metric vessels are being introduced into the fleet, shipboard training and preparation for the "sea year" involves continuing metric indoctrination. Similarly, as the navigational charts are converted to the metric system, additional training will be conducted. The Academy intends to purchase its military uniforms according to metric sizes.

e) National Highway Traffic Safety Administration (NHTSA). NHTSA's primary mission is to reduce the number of fatalities and injuries resulting from motor vehicle crashes. To accomplish this, NHTSA promulgates Federal Motor Vehicle Safety Standards (FMVSS). NHTSA works with the state governments to improve traffic safety at the state and local levels through grants and demonstration programs. It also enforces the FMVSS and conducts research to support the agency's programs.

Due to the complexity of addressing the highway safety problems, NHTSA has adopted a multi-faceted approach for implementing its metric transition. Each facet affects a different constituency and considers the requirements for these groups.

For the groups already acquainted with the metric system, hard conversion will occur in a relatively short time frame. For the remainder, a dual system will be used with complete conversion occurring after an extended time period.

The following are brief descriptions of the NHTSA programs and transition plan highlights:

Rulemaking. Federal Motor Vehicle Safety Standards (FMVSS) issued after May 8, 1992 will be based on the metric system whenever possible. All regulatory actions, in order to prevent degradation of safety, will utilize administrative procedures.

Research and Development. All research contracts are to be issued using metric units. As of May 8, 1992, metric units will be used in all reports, papers, and other documents except for issues concerning highway speed limits. The Office of Crashworthiness Research. The signal analysis software was modified, tested, and operational on March 1, 1992. This includes a pre-processing program to convert time history files to metric units and a new subroutine to ensure that correct units and scales are used. On-line database resources are to be converted by March 1, 1992. These include: Safety Performance Databases, Vehicle Database, Component Database, Biomechanics Database, and Crashworthiness State Database. The Vehicle Research and Test Center (VRTC) is able to generate data in the whatever measurement units are used by the respective databases (metric and/or inch-pound). The National Center for Statistics and Analysis, Math Analysis Division, is to use metric units in its work beginning May 1991; the Accident Investigation Division, responsible for collecting crash data, will convert to metric standards over a 3-year period beginning in FY '92; the Office of Driver and Pedestrian Research's research and development efforts in support of traffic safety programs will be converted according to the overall R&D schedule; and the Office of Crash Avoidance Research used metric units since May, 1991.

Enforcement. Metric conversion will require the revision of all investigative and contract reports, test notes and reports, briefings and presentations, and test procedures. Test procedures will be converted to metric units within a 3 to 4 year period after conversion of the corresponding standard(s).

Traffic Safety Programs (TSP). TSP's transition will primarily involve the occasional reference to weights and measures contained in TSP publication material. TSP's implementation will be in three phases: Phase I - From May 8, 1992 through May 7, 1994, new documents will include inch-pound units as the primary value, followed by the metric equivalent appearing in parenthesis. Phase II - From May 8, 1994 through May 7, 1997, new documents which contain weights and measures will include the metric measurement as the primary unit, followed by the inch-pound equivalent appearing in parenthesis. Phase III - After May 8, 1997, all documents prepared by TSP which contain weights and measures will include only the metric value. All reprinted documents will be revised to reflect the metric measurements even if other substantive modifications are not required.

Regional, State, and Local Offices. The metric transition for the Regional Offices will follow TSP's schedule. The 402 grant program which is managed through the Regional Offices will involve additional demands placed directly on the States and local governments. These requirements apply to their grant applications and Annual Highway Safety Program which will be contained in the 402, 408, or 410 grant agreements and guidance that is provided to the grantees.

Excluded Programs. Fuel Economy Standards: Title V of the Motor Vehicle Information and Cost Savings Act (Improving Fuel Economy), 15 U.S.C., Section 2001, et seq., requires motor vehicle manufacturers to meet corporate average fuel economy (CAFE) standards, as set forth in the statute, or as determined by the Secretary of Transportation. The statute specifically defines fuel economy in inch-pound units; accordingly, CAFE standards will be inch-pound units. Odometer Disclosure Requirements: Title IV of the Motor Vehicle Information and Cost Savings Act (Odometer Requirements), 15 U.S. C., et seq., prohibits the tampering of odometers and establishes safeguards for the protection of motor vehicle purchasers by requiring written disclosures of the mileage in connection with the transfer of ownership of the vehicles. The statute governs the actions of individuals possessing the vehicle, not the vehicle itself. A change to kilometers would require that every odometer in every vehicle would have to be converted.

International Standards. Changing to the metric system is expected to enhance the agency's harmonization program.

Private Sector Considerations and Impacts. NHTSA's primary impact on the private sector is through regulations that affect the manufacturing of motor vehicles. This is now largely accomplished using metric units. Additional impact provided through its programs that communicate safety messages to the general public. These instruments will use the dual system during the seven year transition period. Accordingly, this should be a reasonable time for the general public to be accustomed to the metric units

f) Research and Special Programs Administration (RSPA). Highlights of RSPA's transition plan are organized according to the following subunits

Office of Hazardous Materials Safety. This Office carries on a national safety program and oversees the regulations and regulatory actions governing the safe transportation of hazardous materials. Much of the metric conversion of Hazardous Materials Regulations has been completed. Research contracts are to be written to request the use of SI measurements for study findings and reports. Training needs include conversion tables and brief staff training with minimal budgetary impact. The republication of some RSPA informational material will also be necessary.

Office of Pipeline Safety (OPS). The OPS carries out a national regulatory program for the safe transport of hazardous materials by pipeline. It also issues grants to State pipeline organizations. The OPS will be making metric changes in the following areas: Pipeline safety regulations, reporting and record keeping, forms and checklists, and publications.

Office of Emergency Transportation. This office, which oversees the transportation civil emergency preparedness and response policy and plans, recommends a dual measurement system until all locations and dimensions of assets and facilities are converted.

Office of Airline Statistics (OAS). The OAS collects, disseminates, and retains air carrier financial and operating statistics in support of major DOT programs. To determine the extent and impact of conversion, OAF intends to perform surveys of airline data users (OAS, FAA, RSPA, other Government agencies, and the private sector) and the providers (airlines). Regulations are to be revised, as well as OAF manuals, documents,

publications, and computer systems. Historical databases will also require revision to accommodate trend analysis. Also, training will have to be provided to users of airline data. Furthermore, careful attention will be necessary with the coordination of FAA safety monitoring systems and the revised RSPA data collection system.

Office of Research Policy and Technology Transfer. This Office conducts a program of research and development and disseminates the technical information to the transportation community. As part of the effort, the radio-navigation and communications programs are already using S1 measurements.

Transportation Safety Institute (TSI). TSI serves as the primary source for DOT safety and security training and technical assistance. Since the sponsoring DOT agencies are responsive to the respective industries that it serves, the training criteria is defined by their needs. TSI'S metric transition will be driven by the FAA conversion plan.

Office of Automated Tariffs. The Office of Automated Tariffs is responsible for air carrier tariff filings which are subject to various inch-pound standards contained in CFR 221, Tariffs. These regulations are followed by the airlines when requesting approval for tariffs. Consultation with the Airline Publishers Company and the international Air Transport Association will be required concerning the conversion. The automated computer program for filing international airline tariffs that is used by the Airline Publishers Company is excluded. RSPA will apply for an exception in accordance with the Executive Order. Furthermore, the term "Maximum Permitted Mileage" (MPM) is recognized worldwide to construct fares between any two points in the world.

Office of University Research and Education. The Office of University Research and Education acts as the point of contact with the academic community for RSPA and DOT. It administers and monitors the University Transportation Centers Program and awards grants under the Surface Transportation Act. Currently, there are no grant requirements for the use of the metric system; however, new guidelines are being drafted for the next generation of grants. The performance requirements for metric conversion of units set forth in DOT Order 1700.18B will apply for the publication of scientific and technical reports.

g) Saint Lawrence Seaway Development Corporation. Since 1975, water flows, water levels, water temperatures, and ice thickness in the Saint Lawrence Seaway have been recorded in metric units as requested by the International Joint Commission. In addition, water usage and regulated data have been in metric since that date. In 1977, the Corporation converted its operational activities to the metric system. Accordingly the Seaway Regulations and notices to mariners have been published using metric units. The affected measurements are: cargo volumes, vessel dimensions, vessel drafts, lock dimensions, mileage markers, bridge signs, and lock wall markings. In addition, the navigation charts for the seaway have been converted to metric units by the National Ocean Service of NOAA and Canadian Hydrographic Services and are in the process of being printed.

h) Federal Transit Administration (FTA). Due to the nature of the major activities in which FTA is involved, it plays a major role in providing guidance for metrication rather than requiring conversion through rule making. Due to its multi-national markets, much

of the industry that supports FTA has been actively converting to the metric system. Elements of the FTA plan are as follows:

Office of Grants Management (UGM). UGM collects data and apportions funds largely based on various size and distance measurement parameters. Currently, grant applications indicate vehicle, passenger, and fixed guideway route distances in miles. FTA's computers process and store this data in that form. To accommodate conversion, revised letters of intent to potential grant applicants will be issued, Circulars describing the new metric requirements will be required, and training in the use of the new system will be necessary.

Office of Technical Assistance and Safety (UTS). UTS is responsible for coordinating FTA's implementation. Since its information systems are principally maintained using the Section 15 reports, the converted data will appear as the using offices update their reports.

i) U.S. Coast Guard. The Coast Guard's metric conversion plan is based on 13 defined operating tasks, each with organizational provisions, definitions of actions required, statements of scheduled completion and goals, and responsibility for implementation and reporting. The following is a summary of the Coast Guard's task completion dates:

Transition Management	February 1992
Operations, Safety, and Interoperability	
initial	August 1994
Complete	October 1997
Logistics, Commodities, Test & Evaluation, and Diagnostic Equipment	
Initial	September 1994
Complete	October 1997
Procurement Specifications and Standards	
Initial	October 1992
Complete	October 1993
Education and Training	
Initial	May 1995
Complete	September 1997
Construction	
Initial	July 1995
Complete	October 1997
Electronics	
Initial	June 1993
Complete	October 1997
Clothing and Textiles"	
Initial	July 1995
Complete	October 1997
Health	
Initial	May 1994
Complete	October 1997
Public Affairs	
Initial	June 1993
Complete	October 1997

Metrication Handbook	Initial	October 1992
	C o m p l e t e	October 1993
Food	Initial	October 1993
	Complete	October 1994

6. Significant Developments

a) The **Federal Aviation Administration (FAA)** will revise its procurement process in fiscal year 1992 to ensure that metric measurements are used as required, unless appropriate justification is provided. A Quality Action Team will be considered to deal with problems in this area. The FAA will periodically meet with industry associations to discuss problems in implementing metric policy. Program and contracting officials will be educated through the use of training sessions, teleconferences, and updates on progress in awarding metric contracts.

A primary area of activity in the FAA is the provision of grants for airport development. Action has already been taken to begin voluntary conversion to the metric system. This has been achieved during preparation of advisory circulars used by airports to design and construct airport projects with grant assistance.

The primary business-related activity of the FAA is the operation of the air traffic system and regulation of the aviation community. The international community has recognized U.S. customary standards and the U.S. has maintained the position that any proposed procedural change should be in response to a clearly defined problem. To date, the use of the non-international system of units (the foot and the nautical mile) has not been perceived to be a safety problem. To the contrary, safety problems could arise during the transition phase to the metric system, especially in the cockpit when converting measurements of height, altitude, and elevation. Consequently, the FAA has no plans at this time to support metric conversion, domestically or internationally through ICAO. Nevertheless, the Research and Development Service plans to conduct a safety impact study on metric conversion in cooperation with the Office of Safety Oversight. As the manufacturing sector of the aviation industry undergoes transition to the metric system, the FAA will accommodate metric measures in aircraft specifications as new aircraft are certified.

b) For the **Federal Highway Administration (FHWA)**, two significant developments have occurred that are favorable to metric conversion of the highway program. First Congress, in the Intermodal Transportation Authorization Act removed all restrictions on the use of metric measures on highway signs on Federal aid highways. FHWA is considering the complex factors involved in highway signing, including dual metric and inch-pound signing, the rounding off of speed limits in highway signs, amendments to the Manual on Uniform Traffic Control Devices and other traffic standards, public education, and traffic laws. The second development is the formation of a task force with AASHTO to review engineering specifications and federal aid regulations with respect to the use of the metric system in state highway construction where federal aid is authorized.

c) The **Federal Railroad Administration (FRA)** is already requiring the metric system as the primary measurement system for its research and development contract solicitations. The FRA, as the lead agency in the National Maglev Initiative, is requiring metric units of measurement. In solicitations for contracts, S1 has been identified as the preferred measurement system. Responsive bidders are required to submit proposals in metric units, but are allowed to include the inch-pound equivalent in parentheses. Contract language will require metric units in all deliverables.

To determine whether FRA safety regulations should be excluded from a metric-only standard, it has requested data from the American Association of Railroads (AAR), the American Short Line Railroad Association (ASLRA), and the Regional Railroads of America (RRA), on the costs and benefits to the railroads of complying with FRA regulations published in both metric and inch-pound. The Railway Progress Institute (RPI), which is a trade association of railroad equipment suppliers, has been asked to provide similar information with respect to the equipment supply industry. RPI has been specifically asked to respond to the issue of metric impact on international competitiveness of railroad suppliers. The Local Rail Freight Assistance Program (LFRA) will be analyzed to determine if its regulations warrant exclusion from conversion to metric. The FRA has requested information from the ASLRA, RRA, and the National Conference of State Railway Officials (NCSRO) on the impact of the conversion. Also, FRA has requested assistance from Amtrak in evaluating the use of metric standards in Amtrak procurements funded by FRA grants.

d) To accommodate any future ship construction in the U.S., the **Maritime Administration (MARAD)** will complete a metric version of the Standard Specifications for Merchant Ship Construction by July 1994, develop a list that will differentiate metric-built ships from inch-pound-built ships to facilitate replacement part tracking, compile an inventory of ships whose fathometers are inch-pound only and will be targeted for replacement convert cargo weight data in all database systems (pending a determination by MARAD's Associate Administrator for Maritime Aids and Office of Information Resources Management); include in all in-house, contractual, and cooperative study solicitations a provision for utilizing metric units in the final report; make program modifications to the Maritime Statistical Information System (MSIS) to permit the capture and display of metric data as it relates to port development.

e) The **National Highway Traffic Safety Administration (NHTSA)** will base Federal Motor Vehicle Safety Standards (FMVSS), whenever possible, on the metric system. During the period before May 7, 1997, an orderly review will be performed on all FMVSS's currently in force. This review will be the basis for scheduling revisions to Standards in the upcoming years. For those cases where the conversion to an equivalent metric unit results in slight changes to the performance levels of the FMVSS, a composite rulemaking will be undertaken in the subsequent year if feasible. Odometer disclosure and fuel economy standards are not scheduled for conversion at this time. All new investigative reports, test and survey reports, contracts, and other documentation will be issued using metric equivalents. Traffic safety programs, including grants to state safety agencies, will undergo a less aggressive conversion than motor vehicle programs. The traffic safety programs to be converted are the workshop material, training course curricula and public information material, etc. A dual system will be in place during the 5-year, May 8, 1992 through May 7, 1997 transition period and will use equivalent rather than exact metric units. After 1997, all new material will exclusively use metric units. All research reports, contracts, papers,

etc. will contain metric equivalents. All research and development efforts are to be in metric by May 7, 1997. Originators of the Statements of Work (SOWS) will issue contract provisions using metric units. On April 21, 1992, NHTSA published a Federal Register Notice requesting public comment on its metric conversion proposals.

f) In June 1992, the **Research and Special Programs Administration (RSPA)**, published a notice in the *Federal Register* inviting public comments on all aspects of its metric conversion plan. On January 1, 1991, RSPA announced that all U.S. regulations on the transportation of hazardous materials were aligned with international rules based upon United Nations recommendations. A five-year phase-in period is allowed.

g) The **Saint Lawrence Seaway Development Corporation (SLSDC)** will expand the use of the metric system in its Lock Operations and Marine Services area. A listing of metric units to be implemented will be developed in cooperation with the Saint Lawrence Seaway Authority and mariners is scheduled for September 30, 1992. SLSDC will determine which supplies and materials are available in metric units and could be accepted for lock structures, aids to navigation, building and grounds, etc. SLSDC projects that by September 30, 1992, it will establish acceptable metric design requirements for SLSDC structures. Starting in FY '92, procurement specifications will be written using a dual system with inch-pound taking the primary position. In FY '93, metric will take the primary position. Starting in FY '94, and if no major problems are encountered, metric-only measurements will be used. A similar policy will be in effect for the preparation of reports, letters, memoranda, etc.

h) The **Federal Transportation Administration (FTA)** has inaugurated consultation with public transit organizations concerning transition to the metric system in the use of federal transit aid. On March 19, 1992, FTA published a Notice of Proposed Policy in the *Federal Register*. Comments on likely costs, service life of transit rolling stock, and the use of metric measures in the evaluation of land purchases are being assessed.

j) The **U.S. Coast Guard** has constructed 37 fully metric Island-Class patrol boats. Among other equipment, rigid-hull inflatable boats carried on the Island-Class and similar boats are designed to metric specifications, as is the Mk 75, Oto Melara 76 mm high speed cannon, a 25 mm machine gun installed on Island-Class boats, HH-65 helicopters, and Falcon jets (which are designed in metric units, but may include inch-pound equipment and engines).

DEPARTMENT OF THE TREASURY

Although the Department of the Treasury has a limited range of measurement-sensitive activities, some of its bureaus are concerned with specific measurement-sensitive activities. For example, the Mint and the Bureau of Engraving and Printing are concerned with the technical dimensions of materials. The Customs Service is concerned with the weights, measures, and values of goods and services in international trade, thereby encountering regularly packages and documents that are stated in metric units. Other bureaus, such as the Internal Revenue Service, Bureau of the Public Debt, and Savings Bond Division are financial bureaus concerned with dimensions of documents and statistical presentations. (The IRS is probably the second largest document-printing organization after the Government Printing Office.)

Pages 71-79 are not included in this appendix.
They are irrelevant to the report's subject.

a) **Transition Management.** The transition management structure that is established by the plan will be responsible for obtaining Directorate- and component-level implementation plans, maintaining a reference library of metric transition publications and related items, and creating and maintaining a management information system to monitor and report on all transition tasks.

b) **Education and Training.** All CIA personnel are to be made aware of the requirement to use metric and how and when this will be accomplished. Agency-wide notices, brochures, and other types of materials explaining the metric system of measurement and the need to use it will be distributed. The extent and type of training will vary by Agency component. Most personnel will require a working knowledge of the metric system, while others will need more specific, detailed training.

c) **Specifications and Standards.** Specifications for all measurement-sensitive items procured by CIA after September 30, 1992 will be in metric units, unless an exemption has been granted. This includes items purchased by, as well as those developed uniquely for, the Agency. Metric conversion applies to new systems procured or developed after September 30, 1992, unless exemptions are granted or the new system interfaces an existing system designed in non-metric measurement units.

d) **Design and Construction.** This portion of the plan covers the actions necessary to determine the feasibility and availability of using the metric system in the Agency's construction projects. Highlights of this part of the plan include:

- Changing from inch-pound units to "soft" metric units or dual units to motivate personnel and contractors to use the S1 system;
- Monitoring (through the MOC Construction Subcommittee) the availability of U.S.-made metric parts and equipment and
- Changing to "hard" metric units when adequate availability of U.S.-made parts and equipment is confirmed.

e) **Procurement and Industry Coordination.** Metric units will be required for all procurements in accordance with the exemption procedures. The Agency will assess the ability of the contractors with whom it deals to provide their products in metric dimensions and will incorporate statements of preference for metric in all contracts and solicitations. This task also involves the development of specialized training and/or briefings for procurement and program personnel to ensure proper preparation of specifications and contract documents.

6. Significant Developments

a) **Transition Management.** The Agency form "Justification for Exemption to Hard Metric Usage," the Headquarters Notice that outlines the requirements of the metric legislation and the Executive Order, and the statement of responsibilities for the metric advocates have been sent to all Agency employees.

b) **Education and Training.** A survey of metric education and training materials is to be conducted. Existing Agency training courses will be modified to include relevant revisions. Metric policy implementation segments are to be included in several courses, in particular, Agency Contracts Process, Agency Contracts Familiarization, and Managing Agency Projects.

c) Specifications and Standards. A metric conversion software program is to be loaded onto the Agency's mainframe computer and a "Tech Note" is to be published to announce the availability of the package.

d) Procurement and Industry Coordination. Agency contract officers shall be attaching metric policy statements to their contractual documents with a request for contractors to respond with their capabilities for or impact of providing products in S1 dimensions. Also, CIA is drafting solicitation and contract clauses that state its metric policy and request contractors to describe their capabilities to provide products or services in metric units.

FEDERAL COMMUNICATIONS COMMISSION (FCC)

The FCC plan indicates that the telecommunications industry has largely converted to the metric system. The FCC will issue public notices on its own metric conversion activities, mainly in the area of procurement, which will be completed in 1992.

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

FEMA expects that its metric transition policy will be in effect by September 30, 1992. The policy is to review publications prior to reprinting them to determine whether measurement citations in the document can be converted to metric units.



FEDERAL MARITIME COMMISSION

The main impact of the Federal Maritime Commission on the maritime industry is in the Commission's procurements and in tariff conversions. The plan notes the diversity of measurements used throughout the world and the need to computerize tariff filing and publication. The Commission will cooperate with the desires of the appropriate sectors of the international shipping enterprise.

FEDERAL TRADE COMMISSION (FTC)

The FTC plan notes the complexities of labeling of consumer goods and conversion of FTC regulations and advisories to metric units. The Commission plans to extend some of its consumer and business education material to incorporate the use of metric units. For those measurement-sensitive procurements not covered by GSA schedules, the FTC will seek to educate prospective small contractors about government metrification by distributing appropriate Small Business Administration or other brochures and materials. Where suitable, the FTC will encourage contractors to bid on measurement-sensitive procurements using metric as well as inch-pound measurements.

GENERAL SERVICES ADMINISTRATION (GSA)

The mission of the General Services Administration, sometimes called the "housekeeper" of the government, is to provide services such as supply services for the entire Federal establishment and to develop suitable policies for the administration


Appendix E

**Metrication of USN Surface Ships, NavSea Metrics Conference, 19 February
1992, Crystal City, VA**

Metrication of USN Surface Ships




Agenda

- Introduction
 - Metric Requirements
 - Metrication Initiatives
 - Definitions
 - NAVSEA Approach to Metrication
 - Proposed Shipbuilder Involvement
 - Discussion
- 




Metric Requirements - Public Law

- **Metric Conversion Act of 1975**
 - *Encouraged Voluntary Use*
 - **Omnibus Trade and Competitiveness Act of 1988**
 - *Metric is the Preferred System*
 - *Mandatory for Federal Agencies by End of FY92*
- 



Metric Requirements - Executive Order

■ EO 12770 of 7/25/91

- *Requires use of Metric System in Federal Procurements to "extent economically feasible" Starting 30 September 1992***
 - *Not Required to the "extent that such use is impractical or is likely to cause significant inefficiencies or loss of markets to US firms"***
 - *Commerce to Direct and Coordinate Transition***
- 



Metric Requirements - DoD Instructions

- **DoDI 5000.2 / SECNAV 5000.2A**
 - ***Metric to be Used in All Elements of New Weapons Systems Requiring New Design***






Current Initiatives

■ USN Boat / Craft

- *MHC 51***
- *YON Fuel Barge***
- *YFN Covered Lighter***
- *Several Utility / Work Boats***

■ Systems and Equipment

- *Propulsion Diesels***
 - *Rescue and Salvage Equipment***
 - *Mine Countermeasures Systems***
 - *Several Combat & C⁴I Systems***
- 



Working Definitions

■ **Soft Conversion**

- *The process of changing a US customary measurement to the equivalent metric measurement. The item does not physically change as a result.*

■ **Hard Conversion**

- *The process of changing a US customary measurement to a non-equivalent metric measurement that usually involves a rounded, rational number. This "conversion" does change the physical configuration of the item.*






Working Definitions (Continued)

■ **Hybrid**

- *A design where some components and/or systems are metric and some are inch-pound.*





NAVSEA Approach

- **New Surface Ship Designs will be Hybrid Metric**
 - *This will include the LX currently starting Preliminary Design*
- **Voluntary Shipbuilder Participation Encouraged as Metric Requirements Evolve**



Planning Assumptions


■ **General**

- *New Surface Ship Designs will Utilize Metric Practice to the Extent that Performance Requirements are Met and no Significant Cost, Schedule or Technical Risk is Involved.*
- *No Intent to Drive Vendor Base by Requiring Redesign to Metric Dimensions*



Planning Assumptions - Continued

■ **Structures**

- ***Hull and Superstructure: Hard Metric Dimensions***
 - ***Plate: Hard Metric***
 - ***Shapes: Standard Shapes w/Soft Metric Dimensions***
- 

Planning Assumptions - Continued

■ Equipment and Systems


- *The use of Non-Developmental Items (NDI) is encouraged. The conversion of such items to metric will not be required.***
- *New equipment / systems will be metric provided there is no issue of exclusion of domestic sources and there is no significant cost, schedule or technical risk.***





Planning Assumptions - Continued

■ Drawings

- *All new drawings prepared by the Navy or the Shipbuilder will be dimensioned in metric units.*
 - *Existing standard drawings and vendor furnished drawings need not be converted.*
 - *Equipment designed in US Customary units will be shown on arrangement drawings with soft metric dimensions.*
- 

Planning Assumptions - Continued

■ Engineering Calculations

- *Metric preferred but not required***

■ MIL-SPECs and MIL-STDs

- *NAVSEA is in the process of converting - resource problems >> slow pace***
- *Clearly a majority of the specifications invoked in near term ship procurements will not be converted***
- *Need to develop guidance on how to apply unconverted documents***



Planning Assumptions - Continued

■ **Engineering Calculations**

- *Metric preferred but not required*

■ **MIL-SPECs and MIL-STDs**

- *NAVSEA is in the process of converting - resource problems >> slow pace*
- *Clearly a majority of the specifications invoked in near term ship procurements will not be converted*
- *Need to develop guidance on how to apply unconverted documents*



Shipbuilder Involvement

■ **Areas of Interest**

- ***Design Tools***
- ***Training***
- ***Production Processes (Machining, Jigging, Shops, Assembly)***
- ***Vendor Base***





Shipbuilder Involvement

■ Near Term - In Support of LX Preliminary Design

- *Design Team will meet with all interested shipbuilders to initiate discussions on metrication areas of interest.***
- *Contact Jim Fowler (703-418-4168) by 26 Februrary to arrange date/time.***



Appendix F

Shipbuilder Survey, with Tabulated Responses

INTRODUCTION OF METRICATION TO U.S. SHIPBUILDING
SURVEY OF SHIPBUILDERS
TABULATION OF RESPONSES

In order to condense the responses from the surveys into tabular form and still maintain the respondents identity for the purpose of identifying patterns, the shipyard respondents are coded by number.

1. What is your company's average employment level?

1 <100 (Respondent #6}
4 100-1000 (" #3, 4, 8) 12)
4 1000-5000 (" #1, 5, 7, 9)
4 >5000 (" #2, 10, 11, 13)

2. What approximate percentage of your average workload is

?_ New construction?

0 % (Respondents #6, 8)
80% (" #1, 2, 3) 12)
90% { " #10, 11)
95% (" #4, 7)
NR (" #5, 9)

?_ Repair/conversion?

5 % (Respondents #4, 7}
10% (" #10, 11)
20% (" #1, 2, 3) 12)
100% (" #6, 8, 13)
NR (" #5, 9)

3. Looking at the past three years and forward to the next three years, what is the average make-up of your source of work?

	RESPONDENTS																	
	7	2	3	4	5	6	7	8	9	1	0	1	1	1	2	1	3	"
___ o/o Government (Navy)	0	-	0	0	0	1	20	55	70	95	85	25	95					
- % Government (Non-Navy)	70	-	5	0	5	0	1	2	5	3	2	0	-	-	5	5		
___ % Commercial (Jones Act/oceangoing) 30	-	30	0	0	78	30	10	0	-	15	20							
- % Commercial (Inland/Coast)	0	-	02	95	¹⁰⁰	15	20	3	30	-	-	40						
___ % Foreign Military Sales	0	-	0	0	0	5	5	0	0	5	-	1	0					

4. On what size vessels is the majority of your workload concentrated?

6 <2000 DWT (Respondents #3, 4, 5, 7, 9, 12)
2 2000 - 10,000 DWT (" #2, 8)
3 10,000 - 50,000 DWT (" #8, 10, 11)
3 >50,000 DWT (" #1, 2, 6)
1 NA (" #93)

The following questions are concerning your company's past experiences in design, procurement, and production to the metric system.

5. Does your company have a stated metrication policy?

1 Yes (Respondent #5)

12 No (" #1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13)

Comments:

#1 - The Company plans to move forward into metrication beginning this year.

#2 - Have done a study on impact, but do not have formal policy.

#3 - Up to 50% of our projects are English or Australian design. It was far easier to issue metric tape measures than to change the drawings.

#5 - We do a lot of foreign work. All engineering in metric.

#6 - We use whatever system of measurement the ship has in use.

#12 We are involved in a metric contract, but as far as a stated metrication policy - no..

#13 Use on reports only (for publication)

6. What is the status of your metrication program?

5 Not planned yet (Respondents #4, 7, 9, 11, 13)

2 In planning stage (" #1, 8)

2 Being Implemented (" #5, 12)

Other/Comments:

#1 - No formal policy.

#2 - Necessary changes will be made as need arises.

#3 - If the project is designed in metric we develop all the working drawings in metric. If it's imperial we leave it that way. It's no problem either way

#6 - N/A

#10 - No program as such. Hybrid metric on Israeli ships.

#11 - While we have no "plan", we are presently doing a four ship program; design and construction, under "HYBRID" conditions.

7. What, in your opinion has been, or is most likely to be the greatest force influencing your company's position regarding metrication. Please rank the following from 1 to 5, with 1 being the most influential and 5 being the least.

	RESPONDENTS															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Customer demand	1/1	1/1	5/5	-/1	1/1	2/2	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
Supplier base (availability, price)			5/5	-/2	1/1	3/3	4/3	2/2	3/3	3/3	2/2	2/3	4/4			
Government/regulatory						5/5	-	4/4	-	2/2	1/1	3/3	2/2	2/2	3/3	4/2
Internal (company) mandate						5/5	3/5	4/4	4/4	4/4	4/4	3/4	3/3			
Other/Comment							5/4	-	5/5	5/5	-					

*Rating are indicated: TODAY / IN FIVE YEARS

Comments:

- #3 - Designer based.
 #7 - Increased sales to foreign markets.

8. What has been your company's experience with metrication?

Check all that apply.

- 7 Performed vessel design using soft metrics (Resp's #1,5, 7, 9, 10,11, 12)
4 Performed vessel design using hard metrics (" #1,3,5,9)
8 Const'd/repai red vessel to soft metric design (" #1,2,4,5,6,7,10,11)
7 Const'd/repai red vessel to hard metric design (" #2,3,5,6,8, 10, 11)
1 Other: No Metrication (" #13)

Comments:

- #2 - Performed preliminary design using hybrid.
 #3 - Designed to hard metric but use imperial standard sizes and shapes based on availability and pricing only.

9. In your company's past experience with metric design, materials, and components, it's likely that there has been some affect on various functions within the shipyard. For the following list, please rate the general effect that metrication has had on each function according to the following scale:

1. HIGHLY POSITIVE
2. SOMEWHAT POSITIVE
3. NO EFFECT
4. SOMEWHAT NEGATIVE
5. HIGHLY NEGATIVE

RESPONDENTS

	11 12 13																
	1	2	3	4	5	6	7	8	9	1	0	1	1	1	2	1	3
Engineering																	
Procurement	3	3	3	4	1	3	3	4	4	4	4	4	4	4	2	-	
Warehousing/Inv. Control/Mat'l Handling				3	3	4	3	1	4	3	3	4	3	3	3	3	-
Prod'n trades (please rate individually)	-		3	1		-	2	-	4	-	3	-	-	2		-	
Hull structural, superstructure erection	3	3	1	3	2	4	4	3	3	4	3	3	4	3	3	-	
Metal fab'n (forming, welding, math'g)	3	3	2	3	2	4	4	2	3	4	3	3	4	3	3	-	
Machinery installation	4	3	1	4	2	4	4	3	2	3	4	2	3	4	2	-	
Electrical/Electronics	5	5	5	4	2	4	3	-	1	3	4	3	4	3	-		
Piping	4	3	1	4	2	4	3	4	4	3	3	2	3	3	2	-	
HVAC (sheetmetal)	4	3	3	3	2	4	3	3	2	3	3	2	3	3	2	-	
Joinerwork & Interior outfitting	4	3	1	3	2	4	3	-	2	3	3	3	3	3	-		
Deck machinery & Rigging	4	3	1	3	2	4	4	3	2	3	3	3	3	3	-		
Paints, Coatings, and floor coverings	3	3	3	3	2	3	3	-	2	3	3	3	3	3	-		
Testing and trials	3	3	3	4	2	3	3	3	3	3	4	3	3	3	-		
Logistics support (spares, manuals}	3	3	3	3	2	3	3	4	4	2	4	3	-				
Administrative, Clerical services	4	3	3	3	2	3	3	4	2	3	3	3	-				
Marketing & Contracts Administration	2	3	2	3	2	3	3	2	2	3	3	2	-				
Other/Comment	-	-	-		-	-	-		-	-	-		-	-			

Comments:

- #4 - Our experience has been solely the installation of foreign engines in a domestic towboat.**
- #5 - We design vessels for construction in our or other foreign shipyards with no real problem.**
- #13- No past experience with metric design**

10. Of the above functions, which do you feel has the potential for being the most adversely affected by metrication and, in turn the potential to most adversely affect your company's profitability? Please name the function and provide a few words of explanation.

Comments:

- #1 - Electrical design. (Due to lack of conversion factors for items such as cable size, wire gauge, etc. Also the U.S. Navy has not converted any electrical systems or standards to metric.)**
- #2 - Tooling and gauging in shops, stocking of fasteners, material storage, will all require dual systems for some time'-**
- #3 - Material Control - During a complete metrication process it may be 10 years before domestic manufacturers have changed over. In the meantime we'll have to stock both metric and imperial sizes and keep them separate with good marking. The costs could be significant.**
- #5 - The problem is with U.S. supplied machinery, materials and equipment. There will always be this interface problem until the standards in the U.S. for such items are changed to metric. Hull is no problem. Actually easier once workers get used to it.**
- #6 - Warehousing - due to the duplication of inventory stock.**
- #7 - Erection of the vessel's frames and bulkheads using soft system leads to cumulative roundoff error and hard system requires metric tools and measuring devices.**
- #8 - (1) Procurement - Locating sources of metric pipe, valves and plate. (2) Warehousing - Segregating metric and English sizes.**
- #9 - Lack of metric sized plate, shapes and piping material.**
- #10 - Accuracy Control related to hull fabrication and erection.**
- #11 - During a transition to full metric, I would expect the most adversely affected to be Engineering, and Procurement which in turn would inevitably impact production. If well engineered, supported by Procurement and if Production force is provided adequate training/tooling, adverse affects to Production would be minimized.**
- #12 - Procurement - in my discussions with the department they are having difficulty in locating equipment/vendors who could supply equipment in metric measurement.**
- #13 - Procurement - Procurement confusion in quantities of material ordered and/or delays in material deliveries**

11. Of the above functions, which do you feel has the potential for being the most positively affected by metrication and, in turn the potential to most positively affect your company's profitability? Please name the function and provide a few words of explanation.

Comments:

- #1 - Purchase of equipment for vessels - Large supplier base in existence.
 - #2 - All of it will contribute to being more compliant with international market needs.
 - #3 - Engineering - metric inputs and outputs from the computer can be directly transferred to drawings or vice versa, minimizing conversion errors.
 - #5 - Hull construction and interface with European and Japanese components.
 - #6 - None
 - #7 - None at this time. If required to use continuously, after a period of time ease of manipulation within system will improve productivity.
 - #8 - Machining - ability to machine parts in standard metric sizes (screw threads, gear teeth, etc.) will increase the customer base available to us.
 - #9 - Ability to compete in foreign markets.
 - #10 - Marketing (international)
 - #11 - Once fully implemented, production would be most positively affected based on ease of system for measurement, assembly and installation followed by engineering with advantages in calculations, dimensional control should also improve.
 - #12 Production and marketing. Marketing can use the fact that (the shipyard) can construct ships in either metric or U.S. measurement (good P.R. for foreign customers) and production, by the fact that they can actually construct a quality product in either measurement system.
12. If your company were to bid on a shipbuilding or repair contract today which specified metric requirements, what general affect would the metric requirements have upon your bid price? Based upon your best judgment, please apply pricing factors to the list of metric requirements using the following scale:
- 1. Would result in a lower bid price.
 - 2. Would not substantially affect bid price
 - 3. Would result in a higher bid price.
 - 4. Would tend to discourage bid submittal

											RESPONDENTS													
											1	2	3	4	5	6	7	8	9	10	11	12	13	
All construction drawings prepared in metrics (materials and components to be in English units)											soft	3	2	2	2	1	2	2	-	1	2	2	2	2
All construction drawings prepared in metrics, with hull plating and structural shapes in hard metric dimensions											soft	3	2	2	2	1	3	3	-	3	2	2	3	2
All construction drawings prepared in metrics, with major system components in hard metric dimensions											soft	3	3	2	2	1	3	2	-	2	2	2	3	2
All construction drawings prepared in metrics, major machinery in hard metric dimensions											soft	3	3	2	2	1	3	2	-	3	2	2	3	2
Entire ship design prepared in hard metrics, all materials and components to be hard metric											3	3	2	2	1	3	3	-	4	3	3	3	3	

Comment:

#8 - N/A - at present we are not involved with drawings and design work.

13. My company's capabilities or lack of capabilities to design and build or repair ships to metric specifications has the following affect upon its potential survival and profitability:

6 Substantially, no affect (Respondents #3, 4, 5, 9, 10, 13)

4 Somewhat of an affect (" #1, 2, 8, 11)

3 A substantial affect (" #6, 7) 12)

Comments:

#1 - The ability to construct/repair using metric specifications will have little or no effect on the yard's survival, although it may have a slight beneficial effect on profitability by allowing the shipyard to bid for work in a larger market place.

#8 - Procuring new machines and tools - expanding machine shop capabilities.

#11 - Current customer requirements do not reflect an urgency to convert to metrication, but a substantial negative effect would result if rapid increase in customer requirements is ahead of in-house preparation for transition.

#12 - In order to survive by being able to compete internationally - metrics is a must!

The following questions are concerning metrication as it affects the industry as a whole. Please respond to them from your company's perspective, but at the same time considering your company as a constituent of the industry.

14. In developing a metrication strategy for the shipbuilding industry, what do you feel is the most important issue to address? Please rank the following in order of importance with #1 being of highest priority.

				RESPONDENTS															
				1	2	3	4	5	6	7	8	9 ¹	0	1	1	1	2	1	3
Inherent resistance to change	3	1	-	-	1	5	3	2	3	4	3	4	3	4	5				
Technical training of employees	5	3	-	2	5	2	1	4	5	3	1	1	4						
Supplier base (price & avail'y)	6	4	-	3	2	3	4	1	2	1	4	2	2						
Customer/reg'y body acceptance	4	5	-	-	3	4	5	3	1	2	5	3	1						
Production facilities & equipment	2	2	-	1	4	1	2	4	4	5	2	5	3						
Other/Comment	*		*																

Comments:

- #1 - Senior management resistance.
 #3 - A well planned and executed Nationwide change over, especially for pipe, hose and fittings. Most materials don't matter whether the items are metric or imperial. Nuts and bolts are already available in metric.
 #8 - All of the above are tied together.

15. What position do you think U.S. Shipbuilding as a whole should take as an industry regarding metrication?

- 3 Reactive, convert only as necessary to maintain pace with the supplier base and customer demand (Respondents #4 [comment], 7, 10)
10 Proactive, assume a leading role in the conversion process (Respondents #1, 2, 3, 4 [comment], 5, 6, 8, 9, 1 1) 12)
0 Inactive, the industry should take no role in metrication

Comments:

- #2 - Be proactive, but this does not mean wholesale overnight change, implement in cost effective manner where it makes sense.

- #13- Proactive in new construction, inactive in repair/conversion

16. How would your company feel about an industry-wide policy and strategy regarding metrication?

- 6 Would support it, but only if compliance were voluntary (Respondents #2, 5[comment], 7, 8, 9, 11)
1 Would support it, but only if compliance were mandatory (" #1)
0 Would not support an industry strategy (" #13)
1 NA
5 Other/Comments:

- #3 - Would support it whether voluntary or mandatory.
 #4 - Not necessary in the inland market.
 #6 - Would support it.
 #1 0 - Would depend on destination of the policy and strategy.
 #12 - Would support it.

17. Which organization do you feel would be most instrumental in facilitating a shipbuilding industry metrication strategy?
- 2 ASTM Committee F-25 (on Shipbuilding) (Respondents #2, 7)
 - 6 National Shipbuilding Research Program (" #3, 4, 10, 11, 12, 13)
 - 0 U.S. Coast Guard
 - 0 Maritime Administration (MARAD)
 - 3 Shipbuilder's Council of America (" #1, 6, 11)
 - 2 A Marine sector within the American National Metric Council
(Respondents #2, 9)
 - 2 Other:
- #5 - No response.
18. Open forum. The issues of metrication usually evoke a wide range of opinions and suggestions. We'd like to hear yours. Please feel free to use this final question to present your views and especially any suggestions for the industry to most rationally deal with these issues.
- #1 - A national policy must exist in order to benefit all yards. This policy must be developed by the builders, suppliers and customers. Once the policy is developed it should become mandatory.
 - #2 - Do not see metrication as having major impact on industry with gradual transition to more commercial work, increased use of metrication will occur with hybrid approach similar to what has occurred in auto industry. This assumes a reasonable approach to issue, not a sudden implementation of hard metrics and required redesign of all domestic machinery and materials.
 - #3- Full metrication involves a recalibration of our minds. For instance human engineering needs to think of an average man's size in millimeters, in calculation of temperatures and pressures, we have no quick frame of reference. A sea trial testing technician will need to put away the old instruments and practice the use of this new system. Keeping piping system components available for vessels with a 50 or 60 year life could initially be a problem, but could slowly be changed over. We're already teaching our kids metric in the schools. We need to intensify that effort until they learn to think metric.
 - #7 - The problem with the implementation is many commercial customers desire English units and to jump from English to metric to English on typical one to two Year contracts would be inefficient in the yards. It would have to be a gradual transition but once full metric is used, the yard should build all to metric.
 - #8 - Dreadnought Marine is investing in CNC machine tooling now to broaden our customer base in the commercial ship repair market. Our current bottleneck is the availability of materials (pipe, valves, etc.) in standard metric specs.
We would be pleased to provide additional information and support for this project.
 - #11 - A major transition, disruptive and costly, is difficult for a struggling industry to take on voluntarily. I believe in the long term benefit - strongly - but it is difficult to imagine shipyards on the verge of extinction making the serious investment required. Metrication of our industry via Government contracts requiring metrics

and, perhaps, providing Government support in training and tooling cost would strengthen the industry for the coming century in a way that few yards could afford to undertake on their own, and few would dare to voluntarily include in a bid for work when the competition might not.

#12 - Metrication is a must in order for shipbuilding to survive internationally. Shipyards should be looking at what's out there past the U.S. coastal boundaries. We can compete internationally - it's a matter of getting our "ducks in a row". One of those "ducks" is metrication.

Appendix G

Shipbuilder Supplier Survey. with Tabulated Responses

INTRODUCTION OF METRICATION TO U.S. SHIPBUILDING
SURVEY OF SUPPLIERS
TABULATED RESPONSES

1. Please list the products and/or services that your company supplies directly to shipbuilders.

Survey responses are tabulated using the following Response No. identifiers.

<u>RESPONSE</u>	<u>MARINE SALES,</u>	
<u>NO.</u>	<u>% OF REVENUES</u>	<u>PRODUCT/SERVICE</u>
1	3 %	Diesel engines & prop'n red. gears
2	30	Planning & Design for repair/mod'n work
3	90	Diesel Engines for Propulsion & generating sets
4	NA	Rudder, Stern Tube bearings
5	NA	Shipbuilding services
6	100	Air Compressors
7	100	Shipbuilding Management & Consulting Services
8	<10	Steam Turbines, parts and service
9	100	Naval Architecture, Design, & Consulting
10	60	Pumps, pump units, parts & service
11	100	Naval Architecture, Design, & Consulting
12	NA	Diesel engines for propulsion and generating sets
13	95	Naval Architecture, Design, & Consulting
14	18	Ventilation Fans
15	40	Machinery control systems
16	100	F. O., L. C). Purifiers, Heat exchangers, filters
17	40	Fittings, valves, & jet pumps
18	100	Pressure gauges & thermometers
19	.2	Hydraulic flanges, fittings, & pumps
20	NA	Commercial Washer/Extractor
21	NA	Steel Fasteners

2. What is the approximate percentage of your total revenues derived from the above products/services?

— %

See the “% Marine Sales” column in the table above.

3. Does your company have a stated metrication policy?

4 Yes (Respondents 1, 3, 5, 20)

17 No (Respondents 2, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21)

Comments:

- #3 - (Our company) has had a metrication policy for over 20 years. It is:

- Convert to the use of metric language in all facets of the organization

- Convert at our own pace.

- Adopt metric standards only when one of the following conditions result; improved design, reduced cost, improved worldwide availability, improved standardization, more salable product.

- Convert now unless it will be less expensive later.

- #2 - Services are performed as required by the customer, whether metric or standard.

- #3 - All of our products (diesel engines) are supplied by our parent company in Germany. Like the rest of Europe, Germany is metricized.

- #4 - Because of our international customer base we use both SI and English units (whichever the customer's drawing uses).

- #5 - All ships are manufactured to hard metrics. However, many U.S. systems are installed.

- #7 - No requirement at present for such a policy.

- #9 - We design for whichever system our client is most comfortable, or whichever system the vessel was originally designed.

- #10 - Will again adopt metric when customers so direct.

- #11 - We will provide engineering drawings and specifications upon request.

- #12 - We are fully hard metric.

- #13 - Metrication for us is by client request.

- #16 - All products except model 14VNZPSN.2 are designed and produced in accordance with A/L 200 (Alfa-Laval Design Practices - Metric).

- #19 - We are distributor. The products we sell are manufactured by others.

- #20 - All equipment designed in metric system.

4. What is the status of your metrication program?

2 Not planned yet (Respondents 6, 7, 8, 14, 15, 17, 18, 19, 21)

1 In planning stage (Respondent 10)

2 Being implemented (Respondents 1, 2, 3, 4, 5, 9, 12, 13, 16)

% complete:

50 % (Respondent 2)

90% (Respondent 1)

100% (Respondents 3, 4, 5, 9, 12, 13, 16)

No Response: (Respondents 11 & 20)

Comments:

#1 - We are well over 90% complete. Things that give us problems are government regulations that are not specified in metric units (emissions), poor availability of metric materials for suppliers, poor understanding of metric units and comprehension of metric values by customers.

#11 - We will provide engineering drawings and specification upon request.)

#20 N/A

5. Please state those products/services listed in Question #1 which are currently available in metric (either hard or soft) configuration?

Responses. keyed to respondent No.:

Comments:

#1 - Because our product is a consumer product the customer can not tell whether it is metric or not. In the early 1970's we began designing in metric units. By 1977 all new drawings were made in metric units. In 1979 we virtually completed our conversion to the use of metric plate and sheet in our plants. In 1988 we began to design product with the use of metric fasteners.

#2 - Some engineering and technical documentation and technical publications have been produced in metric configuration. Logistics, provisioning and configuration are not applicable Design and planning, installation and repair, can be done in metric configuration if required by the customer.

#4 - Approximately 15% of product is hard metric while 25% is soft metric.

#5 - Merchant, Frigate and Corvette type ships.

#7 - N/A

#8 - English units are converted to metric equivalent.

#9 - This varies from ship to ship.

#10 - None except for a few fragmented industrial pumps.

#11 - All the services we provide can be provided in either hard or soft metric as specified by the customer.

#12 - All are available in hard metric - only -

#13 - Our work is easily completed in either system.

#15 - VME computer modules.

#16 - All except 14VN2PSN.S

#17 - 100%

#18 - 75% SOft

#19 - Tube fittings (hard)

#20 - All

6. For those products/services that aren't currently available in metric configuration, when do you foresee them becoming available?

0 by 1995

0 by 1998

2 after 1998 (Respondents 10 & 18)

11 indefinite (Respondents 4, 5, 6, 7 8, 14, 15 16 79)

2 no response (Respondents 2, 3, 9, 11, 12, 13, 17, 20, 21)

Comments:

#1 - Considering the above this question could be answered as we already provide all metric products or we will be all metric when the U.S. becomes totally metric. The later being when the last salesman and customer communicate in metric units and understand them as well as they currently understand non metric units.

#6 - N/A

#11 - All the services we provide can be provided in either hard or soft metric as specified by the customer.

#13 - N/A

#21 - N/A

7. For your general product/service line place a check mark in the appropriate column to indicate the cost in metric configuration as compared to the inch-pound equivalent.

	I N C R E A S E						
	DECREASE	NO CHG	0-10 %	10-20%	20-40%	40-50%	>50%
FIRST UNIT		<u>11</u>	<u>2</u>	<u>1</u>		<u>1</u>	<u>1</u>
FOLLOW UNITS		<u>11</u>	<u>3</u>		<u>1</u>		<u>1</u>

No change, 1st Unit (Respondents 2, 4, 5, 7 8, 9, 17, 12, 16, 18, 27)

No change, 2nd Unit (")

0 - 10% Inc, 1 st Unit (" 17, 19)

0 - 10% Inc, 2nd Unit (" 10, 17, 19)

10 20% Inc, 1st Unit (" 10)

40-50% Inc, 1st Unit (" 15)

>50% Inc, 1st Unit (" " 6)

> 50% Inc, 2nd Unit (" 6)

No Response (m 3, 13, 14, 20) .

Comments:

#1 - This can not be answered by a check mark. (Our company) has reduced internal costs by standardizing on fewer metric sizes of materials and drill diameters. However, we may be paying more for some purchased items because of lower production runs of standard metric materials and components

#3 - For us to supply an engine in Imperial units would be virtually impossible, as all of our drawings, production machinery, tools and material stocks are in metric units.

#13 - N/A

#14 - N/A

8. For your general product/service line place a checkmark in the appropriate column to indicate any change in delivery times for metric configurations as compared to the inch-pound equivalent.

I N C R E A S E							
	DECREA	N CHG		%	0-4	40-5 %	
IR NIT		3		9	5		2
W UNITS		5	9		5		

No Chg, 1st Unit (Resp'ts 1, 2, 4, 5, 7, 8, 9, 11, 12, 16, 17, 18, 21)

No Chg, 2nd Unit (“ 1, 2, 4, 5, 7, 8, 9, 10, 11, 12, 13, 16, 17, 18, 21)

0-10% Inc, 2nd Unit (“ 19)

10-20% Inc, 1st Unit (“ 19)

20-40% Inc, 1st Unit (“ 15)

20-40% Inc, 2nd Unit (“ 15)

> 50% Inc, 1st Unit (“ 6, 10)

> 50% Inc, 2nd Unit (“ 6)

No Response (Respondents 14, 20)

Comments:

#1 - No change.

#3 - For us to supply an engine in Imperial units would be virtually impossible, as all of our drawings, production machinery, tools and material stocks are in metric units.

#14 - N/A

#20 - N/A

9. Open forum. We would like to hear your comments and suggestions. regarding metrication in general and in particular, how it will affect your company's role in the shipbuilding industry.

Comments:

#1 - We welcome any of our customers conversion to use of the metric system. Conversion to the metric system by the shipbuilding industry will not have a measurable affect on (our company).

#2 - Our company responds to the customer's requirements. While most of our work is done in English format we have produced products in metric format and are able to do so for any of our products. Metrication presents no difficulty or added cost.

#3 - Conversion of U.S. shipbuilding to the metric system could reduce our costs and overhead, i.e.: not having to re-draw drawings showing Imperial units , not supplying metric to imperial connectors for flanges, pipes, etc.

#4 - A couple of notes:

- Every effort should be made to standardize a common pressure, currently we work in Pa.**
- Metric is a much simpler system of units**
- Going to metric will not affect our company's role in the shipbuilding industry.**

#6 - Metrication would require a re-design in most, if not all, products in the Ingersoll-Rand line of air compression products. The costs of such a program are prohibitive to our participation basis current return on served market.

#7 - Metrication does not affect our role in the industry. We are of the opinion that the industry is well along in the metrication process; the government is the laggard.

#8 - Our role in the shipbuilding industry is currently shrinking with no sign of reversal. Therefore, we foresee no impact.

#9 - As we deal mainly in the cruise ship industry - and as we all know there unfortunately no cruise ships building in the U. S., we are always using the metric system. Being a U.S. citizen and educated in this country (Fort Schuyler) I was raised with the English system. Having worked with the metric system for 13 years I know I can point out a few distinct advantages from a Naval Architects point of view.

Some advantages of the metric system in Naval Architecture:

(1) When dealing with volumes - cubic meters are readily converted to metric tons of displacement. Since 1000 liters = 1 cubic meter it is very easy to convert volumes of liquids to weight, simply using the correct specific gravity.

(2) The fact that 1 cubic meter of steel weighs 8 metric tons it becomes very easy to find steel weights of a structure that is expressed in square meters and a thickness in millimeters. Simply multiply the area (m²) X thickness (mm) X 8-1000.

(3) As we deal with the European Classification Societies: Det Norske Veritas, Lloyd's Register and Bureau Veritas, you must be familiar with the metric system as the rules are all written in this system.

(4) The obvious is that the U.S. is cutting out a whole market by not being able to supply metric products. Unfortunately the American mentality is just like that with our language - we expect all the Scandinavians, Germans, French & Greeks to speak our language, but we don't feel we have to learn theirs. We have the same view with the system of measurements.

I thought the only good thing President Carter was going to do in his four years was change our system to metric, then he wimped out on that. Just what is 5280 feet anyway - everybody knows a Kilometer is 1000 meters.

My partner was born and educated in Sweden and has lived in this country for 24 years - his view is simple - "the U.S. is crazy not to be on the metric system. "

#10 - Metrication is a hit and miss situation, until an industry gets serious about metrics nothing is going to change. A supplier can't maintain parallel product lines and remain competitive. False starts on metrics come about every 7-8 years. Suppliers will supply what the market and customers demand.

#11 - With the increase in CAD use Engineering drawing in metric will be easier to configure scaling will then be must simpler. There are no significant problems in adopting metric standards for shipbuilding. The most significant problem is institutional.

#12 - Ultimately the USA should fully confirm to World Standards (metric) in order to be an effective supplier outside the USA.

#13 - We have accomplished designs using "soft metrics". Hull and pipe were straight metric but equipment and interfaces (pipe/bolts/gaskets) were a wish-wash combination because some vendors would provide metric and some English unit interfaces.

#16 - Alfa-Laval is a world leader in the design and production of equipment in metrics and has long been enjoying metric simplicity.

#17- Procuring foreign shipbuilding specs are bigger problem than metrication.

#18 - We need a global standard for pressure (KPA, BARS, or KG/CM2).

#19 - Our industry (hydraulics and pneumatics) has not been enthusiastic about embracing the metric system. I think it will be a few more years before the SI system is commonplace.

#20 - Metrication program will not impact on our role in supplying equipment to the shipbuilding industry since we already use the metric system in our design.

#21 - Our company is fully capable of providing metric fasteners at this time; metrication in the shipbuilding industry should not affect our company at all.

Appendix H

PBI Metric Training Course Outline. May 1993

COURSE OUTLINE AND REQUEST FOR
COURSE APPROVAL (CONTINUED)

COURSE NUMBER
COURSE TITLE

421-4

Blueprint Reading - Metrics

COURSE OBJECTIVES:

The student will be able to:

1. Know the terminology of the metric system.
2. Know the decimal (Base 10) number system.
3. know how to convert linear measurement from one system to the other metric\English.
4. Illustrate applications of metric dimensions.
- 5 Compare symbols and drawing orientation of first and third angle projection.
6. Know linear, area and volume calculations using metric conversion constants.
7. Know commonly used metric measuring devices.
8. Know metric measurement notation.

COMPLETION OF THIS PAGE IS OPTIONAL FOR NON-CREDIT COURSES

COURSE NO. <u>421-4</u>	*	*	INSTRUCTOR <u>John Burkee</u>
	*	*	
MODULE/UNIT NO. <u>1</u>	* NWTC	*	
	* INSTRUCTIONAL PLAN	*	DATE <u>5/5/93</u>
	*	*	

GLOBAL COMPETENCY: Introduce the participants to the concepts of the
Metric System

LECTURE TIME 3

LABORATORY TIME _____

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHODS
1. Know the terminology of the metric system.	View video, Discussion and practice sets.	Student will know the basic units of metric measurement observed by check tests.
2. Know the decimal (Base 10) number system.	Discussion and practice sets	
3. Know how to connect linear measurement from one system to the other (metric/ English.	Discussion and practice sets.	

COMPLETION OF THIS PAGE IS OPTIONAL FOR NON-CREDIT COURSES

COURSE NO. <u>421-4</u>	* NWTC	* INSTRUCTOR <u>John Burkee</u>
MODULE/UNIT NO. <u>2</u>	* INSTRUCTIONAL PLAN	* DATE <u>5-5-93</u>

GLOBAL COMPETENCY: Apple SI Metric system concepts to Blueprint Reading and Layout.

LECTURE TIME 6
LABORATORY TIME _____

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHODS
1. Illustrate applications of metric dimensions.	Interpret and make calculations using metric system.	Competency in converting English measure to metric dimensions.
2. Compare symbols and drawing orientation of first and third angle projection.	Show example drawings of positioning methods.	
3. Explain linear, area and volume calculations using metric conversion constants.	Perform conversion calculations	Competency in calculating metric dimensions.
4. Show commonly used metric measuring devices.	Layout of fabrications using metric system.	Direct instructor observation and verbal checking for understanding.
5. Show metric measurement notation.		

Appendix I

Metrics Reference Source Listing

APPENDIX I

METRIC REFERENCE SOURCE LISTING

TRAINING AIDs

"All About Metric", three video tapes with reference manual, instructor guidelines , and masters for transparencies, \$495	MMEI corp.	2447 Lexington Pl. Livermore, CA 94550 510-449-8992
"ASME Steam Tables in SI (Metric) Units for Instructional use", 19p, 1977. No charge	American Society of Mechanical Engineers	11 West 42nd St. New York NY 10036 212-642-4900
'Get Ready for Metrics", light reading booklet introducing metric concepts and rules, 12p, \$.75	U.S. Metric Association	10245 Andasol Ave. Northridge, CA 91325-1504 818-368-7443
"Introductory Metrics", correspondence course.	The Learning and Evaluation Center	515 Market St. Bloomsburg, PA 17815 717-784-5220
"ISO 1000Metric in Industry", describes metric usage from an engineering viewpoint, plus covers purchasing, management, and training. In-house training also available.	S.I. Jacob Associates	43 Westbrook Rd. Hartford, CT 06107 203-521-7924 F= 203-521-7914
"Metric Guide for Educational Materials", 22p	American National Metric Council	1735 N. Lynn St., Suite 950 Arlington, VA 22209 703-524-2007
Metric training aids, a source for charts, books, measuring devices, conversion aids, and other metric oriented items	Blackhawk Metric supply	P.O. Box 543 South Beloit, IL 61080 815-389-2850 FAX: 815-389-2952
"Metrication for the Manager, discusses planning and setting corporate policy for the manufacturing industries, 103p, \$12.00- More, \$15.00 - Nonmem.	Society of Automotive Engineers	Customer Service 400 Commonwealth Dr. Warrendale, PA 15095 412-776-4841

“The Modernized Metric System Explained”, handbook of basic facts, conversion tables and rules for using metric units, 35p, 1976,\$.50	J.J. Keller & Associates Inc.	145 W. Wisconsin Ave. Neenah, WI 54956 414-722-2848
“NOAA Nautical Charts Are Going METRIC!” Brochure explaining metric transition to navigational charts.	National Oceanic & Atmospheric Administration	Chief, Nautical Charting Div., (N/CG2, Coast and Geodetic Survey, NOAA Rockville, MD 20852
Posters, set of 24 four-color humorous posters (43 cm x 58 cm)shipped two at a time on a yearly subscription basis, includes poster frame. \$149.95/year	Marlin Industrial Division	P.O. Box 304 New Haven, CT 06473 800-344-5901 FAX: 203-239-5142
Posters, set of 10 full-color posters (28 cm x 21.5 cm) provide frame of reference reminders of metric measurements. \$19.95 + \$2 S&H	Metric Posters	P.O. Box 4192 Attleboro, MA 02703 508-226-5929
“SI Handbook”, secondary/college level text On practical use of metrics. 55 p, \$5.50	Dennis Brownridge	HC63 Box 3040 Mayer, AZ 86333
“SI Metric for the Workplace”, six tape video/courseware provides in-depth metric training for industry and business professionals, \$2195.00	Workplace Training	520 North Arm Dr. Orono, MN 55364 612-472-2564
"SI Metric Training Guide", 17p	American National Metric Council	1735 N. Lynn St., Suite 950 Arlington, VA 22209 703-524-2007
“SI Prefixes”/16 Major SI Units”, set of tWO blackline ozalid charts (75x155cm & 108x180 cm), \$12.00/set	Dennis Brownridge	HC63 Box 3040 Mayer, AZ 86333
‘Teaching SI’, Teaching hints, student worksheets, & answer keys, 44 p, \$2.50	Dennis Brownridge	HC63 Box 3040 Mayer, AZ 86333

METRIC SUPPLIER DIRECTORIES

“Metric Vendor List”, listing of companies that produce or supply metric-based products, 162P, \$40.00	U.S. Metric Association	10245 Andasol Ave. Northridge, CA 91325-1504 818-368-7443
“Domestic Suppliers of Metric Materials”	The Association for Manufacturing Technology	7901 Westpark Drive McLean, VA 22102
“Freeman Training/Education Metric Materials List”, listing of all types of metric materials (A/V, books, computer software, conversion charts, standards, drafting aids, posters, etc.), 180 p, \$37.00- Mem., \$42.00- Nonmem.	U.S. Metric Association	10245 Andasol Avenue Northridge, CA 91325
“Catalog for Active Learning in science and Math”, includes metric dimensioned learning tools and measuring instruments	Teacher’s Laboratory	802-254-3457 FAX: 802-254-5233

METRIC MATERIAL INFORMATION

“Handbook of Comparative World Steel Standards”, covers standards for plate, shapes, pipes, tubes, & special purpose steels, 550 p, \$200- Mem.	American Society for Testing and Materials	1916 Race Street Philadelphia, PA 19103 215-299-5585 FAX: 215-977-9679
“Metric is Simple”, covers all aspects of metric fasteners, 62p, Free	Bossard International	235 Heritage Ave Portsmouth, NH 03801 FAX: 803-432-4659

MISCELLANEOUS PUBLICATIONS/REPORTS

"Canadian Metric Practice Guide", CAN/CSA-Z234.2, 82p, 1989, \$28.00 Can.	Canadian Standards Organization	178 Rexdale Blvd. Ontario M9W 1R3 416-747-4044
"ANMC Metric Editorial Guide", 16p, \$2.00	American National Metric Council	1735 N. Lynn St., Suite 950 Arlington, VA 22209 703-524-2007
"Glossary of Metric Units", Z351, 57p, 1980, \$13.00 Can.	Canadian Standards Organization	178 Rexdale Blvd. Ontario M9W 1R3 416-747-4044
"Guidance for Companies Considering Converting their Operation to Using the Metric System", 49p	U.S. Metric Association	10245 Andasol Ave. Northridge, CA 91325-1504 818-368-7443
"Guide for the Use of the International System of Units", NIST Special Pub. 811, 34p, 1991, \$2.50	U.S. Government Printing Office	Superintendent of Documents U.S. Government Printing Office Washington, DC 20402 202-783-3238
"1988 Handbook - Equipment", includes dual units, \$114.00	American Society of Heating Refrigeration, and Air Conditioning Engineers	1791 Tullie Circle, N.E. Atlanta, GA 30329 404-636-8400
"1989 Handbook - Fundamentals", SI Edition, \$114.00	American Society of Heating Refrigeration, and Air Conditioning Engineers	1791 Tullie Circle, N.E. Atlanta, GA 30329 404-636-8400
"1990 Refrigeration Handbook", SI Edition, \$114.00	American Society of Heating Refrigeration, and Air Conditioning Engineers	1791 Tullie Circle, N.E. Atlanta, GA 30329 404-636-8400
"1991 Handbook - HVAC Applications", SI Edition, \$114.00	American Society of Heating Refrigeration, and Air Conditioning Engineers	1791 Tullie Circle, N.E. Atlanta, GA 30329 404-636-8400
"The International System of Units (SI)", NIST Special Pub. 330, 56p, 1991, \$3.50	U.S. Government Printing Office	Superintendent of Documents U.S. Government Printing Office Washington, DC 20402 202-783-3238
"Interpretation of the SI for the United States and Metric Conversion Policy for Federal Agencies", NIST Special Pub. 814, 1991	U.S. Government Printing Office	Superintendent of Documents U.S. Government Printing Office Washington, DC 20402 202-783-3238

“The Metric Conversion Planner”, handbook of rules and conversions for the machinist, 42p	Brown & Sharpe	Metric Planning Brown & Sharpe Industrial Products North Kingston, R.I. 02852 401-884-3000
“Metric Editorial Handbook”, Z372, 46p, 1980, \$15.00 Can.	Canadian Standards Organization	178 Rexdale Blvd. Ontario M9W 1R3 416-747-4044
‘A Metric America: A Decision Whose Time Has Come’. report of the Commerce Dept's 197’1. Metric Study.	National Technical Information Service	703-487-4650
“The Metric System and Small Business”, 2 page flier	U.S. Small Business Administration	202-653-6095
“The Metric System: A Review of Industrial Applications”, 1982,\$18.00	Society of Manufacturing Engineers	1 SME Drive Box 930 Dearborn, MI 48121 800-733-4763
“Metric Transition Plan and Activities of Federal Government Agencies, NISTIR 4911”, updated yearly, \$27.00	National Technical Information Service	703-487-4650
“Metric Units of Measure and Style Guide”, 1990, \$1.00	U.S. Metric Association	10245 Andasol Ave. Northridge, CA 91325-1504 818-368-7443
‘Metrication in the Commercial Construction Industry”, report on the challenges of introducing metrication to the construction industry in the Kansas City area, 98p, \$18.00	University of Missouri	Elizabeth Suerth 844 King’s Hwy Liberty , MO 63406
“The President’s Export council supports Efforts to Convert to Metric and Urges Industry to Convert”, Mar ’92 report of the PEC, 2p, S. A.S.E.	U.S. Metric Association	10245 Andasol Ave. Northridge, CA 91325-1504 818-368-7443
“Managing Metrication in Business and Industry”, 203p, 1976	American National Metric Council	1735 N. Lynn St., Suite 950 Arlington, VA 22209 703-524-2007

“Metric in Construction”, bimonthly newsletter discussing metric developments in the federal construction industry.	National Institute of Building Sciences	W. Bremer NIBS 1201 L St.. NW, Suite 400 Washington, DC 20005 202-289-7800 FAX: 202-289-1092
“Metric Guide for Naval Ship Systems Design and Acquisition”, metric requirements and rules for the design and acquisition of Naval ships.	NavSea	Naval Sea Systems Command 2531 Jefferson Davis Hwy. Arlington, VA 22242-5160
“Metric Guide for Federal Construction”, manual of guidelines for the use of metrics in federal construction projects, 34p	National Institute of Building Sciences	W. Brenner NIBs 1201 L St.. NW, Suite 400 Washington, DC 20005 202-289-7800 FAX: 202-289-1092
“Metrication for Engineers”, 1983, \$18.00	Society of Manufacturing Engineers	1 SME Drive Box 930 Dearborn, MI 48121 800-733-4763
SI for HVAC&R”, 11p, 1986, free	American Society of Heating Refrigeration, and Air Conditioning Engineers	1791 Tullie Circle, N.E. Atlanta GA 30329 404-636-8400
"Psychometric Charts SI", Charts 1-7,\$10.00	American Society of Heating Refrigeration, and Air Conditioning Engineers	1791 Tullie Circle, N.E. Atlanta, GA 30329 404-636-8400
“Units and Conversion Charts”, 1991,\$21.95	Institute of Electrical and Electronic Engineers	345 E. 47th St. New York NY 10017 800-678-4333

SOFTWARE

'ConvertFile Conversion Utility", metric conversion software for use with DOS based computers. \$39.95	Vidtrak Technologies co.	216-762-5141
"METRIC-X", converts inch-pound to metric units and vice versa, covers 179 measurement units, 5,25" or 3.5" disk format, shareware, \$24.95 Fee	Orion Development Corp.	P.O. BOX 2323 Merrifield, VA 22116 800-992-8170
Metrix, provides over 100 different metric and inch-pound conversions in 14 categories. for DOS. \$32.95.	TechniWare	P.O. BOX 9632 Scottsdale, AZ 85252 602-949-5418 Fax: 602-998-7418
UNITS, very user-friendly, covering all conversions to and from metric units, Shareware. \$15.00 Fee.		Lars Joseffson Kartvagen 17 S-175 46 Jarfala Sweden

STANDARDS

"American National Standard Metric Practice", ANSI/IEEE 268, 48p, 1982, \$23.00	American National Standards Institute	11 West 42nd St. New York, NY 10036 212-642-4900
"Guide for Identification and Development of Metric Standards", SD-10, 10p, 1990	U.S. Department of Defense	Standardization Documents Order Desk Bldg 40, 700 Robbins Avenue Philadelphia, PA 19111-5094
"Guide for Metrication of Codes and Standards Using SI (Metric) Units", SI-9, 33p, 1980, \$8.00	American Society of Mechanical Engineers	22 Law Dr. Box 2300 Fairfield, NJ 07007 800-834-2763, ext. 426
"ISO 1000, SI Units and Recommendations for Use of Their Multiples and Certain Other Units", 1981, \$32.00	American National Standards Institute	11 West 42nd St. New York, NY 10036 212-642-4900
"Maritime Metric Practice Guide", DoD-STD-1690	U.S. Department of Defense	Standardization Documents Order Desk Bldg 40, 700 Robbins Avenue Philadelphia, PA 19111-5094
"Metric Conversion: Load and Resistance Factor Design Specification for Structural Steel Buildings", (Metric version of the Sept. 86 LRFD Specifications), 159p	American Institute of Steel Construction	Metric Publications AISC One E. Wacker Dr., Suite 3100 Chicago, IL 60601-2001 312-670-5414
"Metric Practice Guide for the Welding Industry", ANSI/AWS A1.1, 1989, \$16.00	American National Standards Institute	11 West 42nd St. New York, NY 10036 212-642-4900
"Metric Properties of Structural Shapes with Dimensions According to ASTM A6M", (Metric version of Part 1 of the Manual of Steel Construction), 92p	American Institute of Steel Construction	Metric Publications AISC One E. Wacker Dr., Suite 3100 Chicago, IL 60601-2001 312-670-5414
"Metric System Application in New Design", MIL-STD-1476A	U.S. Department of Defense	Standardization Documents Order Desk Bldg 40, 700 Robbins Avenue Philadelphia, PA 19111-5094

‘Orientation and Guide for Use of SI (Metric) Units’, SI-1, 1982,\$5.00	American Society of Mechanical Engineers	22 Law Dr. Box 2300 Fairfield, NJ 07007 800-834-2763, ext. 426
“Preferred Metric Units for General Use by the Federal Government”, FED-STD-376B, 1993	National Technical Information Service	5285 port Royal Rd. Springfield, VA 22161
“Preferred Metric Units for Use in Electrical and Electronics Science and Technology”, ANSI/IEEE 945, 1984,\$23.00	American National Standards Institute	11 West 42nd St. New York NY 10036 212-642-4900
“SI Units in Dynamics”, SI-3, 20p, 1976,\$5.00	American Society of Mechanical Engineers	22 Law Dr. BOX 2300 Fairfield, NJ 07007 800-834-2763, ext. 426
“SI Units in Fluid Mechanics”, SI-5, 36p, 1976, \$6.00	American Society of Mechanical Engineers	22 Law Dr. Box 2300 Fairfield, NJ 07007 800-834-2763, ext. 426
SI Units in Heat Transfer”, SI-7, 36p, 1977, \$6.00	American Society of Mechanical Engineers	22 Law Dr. Box 2300 Fairfield, NJ 07007 800-834-2763, ext. 426
“SI Units in Kinematics”, SI-6, 14p, 1976,\$5.00	American Society of Mechanical Engineers	22 Law Dr. Box 2300 Fairfield, NJ 07007 800-834-2763, ext. 426
"SI Units in Therrinodynamics”, SI-4, 55p, 1976, \$8.00	American Society of Mechanical Engineers	22 Law Dr. Box 2300 Fairfield, NJ 07007 800-834-2763, ext. 426
"SI Units in Strength of Materials" , SI-2, 14p, 1976, \$6.00	American Society of Mechanical Engineers	22 Law Dr. BOX 2300 Fairfield, NJ 07007 800-834-2763, ext. 426
"SI Units in Vibration", SI-8, 13p, 1976,\$5.00	American Society of Mechanical Engineers	22 Law Dr. Box 2300 Fairfield, NJ 07007 800-834-2763, ext. 426

‘Standard Practice for Use of the International System of Units (SI)”, ASTM E380, 35p, 1989,\$18.00	American Society for Testing and Materials	1916 Race St. Philadelphia, PA 19103 215-299-5585
“Standard Practice for Use of SI Units in Maritime Applications”, ASTM F1332-91	American Society for Testing and Materials	11 West 42nd St. New York NY 10036 212-642-4900
‘steam charts, SI (Metric) and U.S. customary Units”, SI-10, 128p, 1976, \$13.00	American Society of Mechanical Engineers	11 West 42nd St. New York NY 10036 212-642-4900

Appendix J

MIL-STD 1476B, "Metric System Application in New Design"

APPENDIX J

MIL-STD-1476B MI ■ 9999911 0099954 9 ■

NOT MEASUREMENT
SENSITIVE

MIL-STD-1476B
10 May 1991
SUPERSEDING
DOD-STD-1476A
19 November 1986

MILITARY STANDARD

METRIC SYSTEM
APPLICATION IN NEW DESIGN



AMSC N/A
DISTRIBUTION STATEMENT A.
unlimited.

AREA MISC
Approved for public release; distribution is

NOT MEASUREMENT SENSITIVE

NOTICE OF CHANGE

MIL-STD-1476B
NOTICE 1
23 August 1991

MILITARY STANDARD

METRIC SYSTEM APPLICATION IN NEW DESIGN

TO ALL HOLDERS OF MIL-STD-1476B:

1. THE FOLLOWING PAGES OF MIL-STD-1476B HAVE BEEN REVISED AND SUPERSEDE THE PAGES LISTED:

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
2	10 May 1991	2	23 August 1991
3	10 May 1991	3	23 August 1991
6	10 May 1991	6	23 August 1991

2. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

3. Holders of MIL-STD-1476B will verify that page changes and additions indicated above have been entered. This notice page will be retained as a check sheet. This issuance, together with appended page(s), is a separate publication. Each notice is to be retained by stocking points until the military standard is completely revised or canceled.

Custodians:

Army - MI
Navy - SH
Air Force - 01

Preparing Activity:

Army - MI

(Project No. MISC-0142)

Review activities:

Army - AV
Air Force - 70, 71, 80, 82, 84, 99
DLA - GS

User activities:

Navy - YD
Air Force - 90

AMSC N/A

AREA MISC

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

MIL-STD-1476B

FOREWORD

1. This military standard is approved for use by all Departments and Agencies of the Department of Defense.
2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, U.S. Army Missile Command, ATTN: AMSMI-RD-SE-TD-ST, Redstone Arsenal, AL 35898-5276 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.
3. This standard is intended to be referenced only in those contracts for which a decision has been made to design an item, equipment, or system in metric units.
4. Care must be exercised in specifying metric components because if they are specified prior to industrial production to adopted national metric standards, it could result in: (a) nonstandard metric configurations, (b) unnecessary items in the supply system and (c) extra costs because DoD contracts might absorb initial conversion costs of the producing industries.
5. It is usually more practical to design and produce a "new" item, equipment, or system in metric than to convert existing designs or production hardware. This standard requires: (a) that new designs for the end items under contract be designed and expressed in metric units, and (b) that existing metric designed components (parts and assemblies) be selected providing they are technically adequate and available at an equal or lower life-cycle cost.
6. During an extended period of changeover to the use of the metric system on a national basis, commercial and other already-designed components will be available in a mix of straight inch-pound, hybrid and metric designs.
7. Tailoring of the use of this standard to meet the requirements of specific contract is encouraged.

MIL-STD-1476B

CONTENTS

<u>PARAGRAPH</u>		<u>PAGE</u>
1.	SCOPE	1
1.1	scope	1
1.2	Purpose	1
2.	APPLICABLE DOCUMENTS	2
2.1	Government documents	2
2.1.1	Specifications, standards, and handbooks	2
2.2	Non-Government publications	2
2.3	Order of precedence	3
3.	DEFINITIONS	4
3.1	Dual dimensions	4
3.2	Dual indication	4
3.3	Hard conversion	4
3.4	Hybrid	4
3.5	Inch-pound units	4
3.6	Metric design	4
3.7	Metric, metric system, metric units	4
3.8	Soft conversion	4
4.	GENERAL REQUIREMENTS	5
5.	DETAILED REQUIREMENTS	6
5.1	Metric units	6
5.1.1	Preferred units	6
5.2	New design	6
5.3	ExiSting items	6
5.3.1	Material sizes --	6
5.3.2	Components	6
5.3.3	Instrumentation	6
5.4	Modification of existing inch-pound designs	6
5.5	Technical documentation	7
5.5.1	Engineering drawings	7
5.5.2	Specifications	7
5.5.3	Other technical data	7
5.5.4	Interfaces	7
5.5.5	Inch-pound and metric equivalents	7
5.5.6	Metric identifier	7
6.	NOTES	8
6.1	Intended use	8
6.2	Issue of DODISS	8
6.3	Subject term (keyword) listing	8
6.4	Changes from previous issue	8

MIL-STD-1476B

1. SCOPE

1.1 scope. This standard covers the general requirements for employing the metric-system of measurement in new design and in accompanying documentation.

1.2 Purpose. The purpose of this standard is to describe how the metric system will apply to new design or existing subsystems/equipments, during design of new systems (ships, aircraft, missiles, etc.), in the selection of materials and components, and for configuration and functional description in accompanying documents.

MIL-STD-1476B
NOTICE 1

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

STANDARDS

FEDERAL

FED-STD-376 - Preferred Metric Units for General Use by the Federal Government

MILITARY

MIL-STD-970 - Standards and Specifications, Order of Preference for the Selection of

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Ave., Philadelphia, PA 19111-0994).

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E 380 Standard for Metric Practice

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC. (IEEE)

IEEE 268 - Standard Metric Practice

(Application for copies should be addressed to the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.)

Supersedes page 2, dated 10 May 1991.

MIL-STD-1476B
NOTICE 1

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents may also be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, 'however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

Supersedes page 3, dated 10 May 1991.

MIL-STD-1476B

3. DEFINITIONS

3.1 Dual dimensions. A former practice which included linear dimensions in views of a drawing in both metric and inch-pound units.

3.2 Dual indication. The inclusion, in text or on instrumentation and gaging, of a quantity (characteristic or dimension) in both metric and inch-pound units (for example: 700 kPa (100/lbf/in²)).

3.3 Hard conversion. The process of changing inch-pound measurement units to non-equivalent metric units which necessitates physical conversion changes outside those permitted by established measurement tolerances. NOTE: Although the term "hard conversion" is in general use, it is technically incorrect when applied to specific items because no "conversion" takes place. Instead, a new metric item requiring new item identification is created to replace the customary item. The new item is often referred to as being in "hard metric".

3.4 Hybrid. A combination or mixture of metric and inch-pound items.

3.5 Inch-pound units. The customary system formerly and currently used in the United States (foot, inch pound, BTU, horsepower, degree Fahrenheit, etc.) .

3.6 Metric design. Product design using metric dimensions, selected as appropriate, without considering conceptual or physical conversion from inch-pound units.

3.7 Metric, metric system, metric units. The International System of Units (commonly abbreviated as SI), as established by the General Conference of Weight & Measures in 1960 and as interpreted or modified for the United States by the Secretary of Commerce.

3.8 Soft conversion. The process of changing inch-pound measurement units to equivalent metric units within the acceptable measurement tolerances without changing the physical configuration. In other words, it is the same both before and after conversion.

4. GENERAL REQUIREMENTS

This section is not applicable to this standard.

MIL-STD-1476B
NOTICE 1

5. DETAILED REQUIREMENTS

5.1 Metric units. Metric units, practices, and usages shall be in accordance with ASTM E 380 and IEEE 268.

5.1.1 Preferred units. Unless otherwise specified, the preferred metric units for the commonly-used quantities shall be in accordance with FED-STD-376.

5.2 New design. New items designed under contract shall be of metric design. Hybrid design, however, is acceptable where required to accommodate existing customary items selected in accordance with 5.3. Where applicable U.S. Government, non-Government (adopted for use by DoD), U.S. National or international documents exist which establish preferred metric modular sizes or other design standards, they shall be used to the maximum practical extent. Where a U.S. standard is established with greater definition or restriction than a prevailing international standard, the U.S. standard shall apply.

5.3 Existing items. Existing items shall be selected for use in accordance with the following guidelines, giving due consideration to interchangeability.

5.3.1 Material sizes. Metric sizes (e.g., sheet, plate, bar, rod, wire, etc.) shall be used when no cost or performance penalty will be incurred, or when additional first cost is justified by other considerations.

5.3.2 Components. Components shall be selected as follows:

a. Items designated as metric items in documents identified in Groups I, II, and III of MIL-STD-970.

b. All other items on the basis of lowest life cycle cost, whether metric or inch-pound.

5.3.3 Instrumentation. Unless otherwise specified or required by international agreement, instrumentation and gaging (temperature, pressure, etc.) shall show the indications in metric units. The actual construction of the instrument or gage may be either metric or inch-pound in accordance with 5.3.2.

5.4 Modification of existing inch-pound designs. Unless otherwise specified, the extent to which metric design is required in the modification of existing inch-pound designs shall be determined on an individual case basis, considering technical and economical feasibility or other factors.

Supersedes page 6, dated 10 May 1991.

5.5. Technical documentation. Technical documentation shall comply with “the following:

5.5.1 Engineering drawing.

- a. New design. Values shall be expressed in metric units.
- b. Existing design (including control drawings). values shall be expressed in the unit system in which the item or items were designed.
- c. Modified customary design. On new drawings prepared to describe new versions of existing inch-pound & designs, values shall be expressed in the unit system 1 applied to the modified portion of the design. When metric conversion of any part of the & design is required, applicable values shall be expressed in metric units.

5.5.2 specifications. Specifications prepared shall use the terminology of the unit system in which the item is to be designed.

5.5.3 Other technical data. Technical manuals, test reports, and other technical & data shall use the terminology of the unit system in which the item is designed.

5.5.4 Interfaces. For features that interface between inch-pound and metric items, inch-pound and metric equivalents shall be specified directly on the drawing or in the document in accordance with 5.5.5.

5.5.5 Inch-Pound and metric equivalents. Unless otherwise specified, the use of both inch-pound and metric equivalents is optional, except as required by 5.5.2, 5.5.3, and 5.5.4. Dual dimensioning (see 3.1) shall not be used, except that if dual dimensioned drawings exist prior to the issue of this standard that are otherwise acceptable they may be used. When equivalents are Included, they shall be specified as follows:

a. Dual indication (see 3.2). The metric value shall be stated first followed by the inch-pound value in brackets.

b. Tabular form. Unless otherwise specified, table(s) may be included directly on the drawing or document. It shall translate all required values from one system of units to the other in ascending or descending order.

5.5.6 Metric identifier. A metric identifier, that is the word “METRICK”, preferably enclosed in a rectangle, shall be placed on the field of the drawing near the title block. On other technical data, it shall be located in the vicinity of the document number. Lettering size shall be approximately the same as the drawing or document number. When nonmetric sheets are included in a metric document. the identifier shall be placed on each metric sheet only.

MIL-STD-1476B

6. NOTES

-(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This standard is intended to be referenced as a guide for applying metric measurements in new design and accompanying documentation.

6.2 Issue of DODISS. When this standard is used in acquisition, the applicable issue of the DODISS must be cited in the solicitation (see 2.1.1 and 2.2).

6.3 Subject term (keyword) listing.

Hybrid
International Bureau of Weights and Measures
"Le Systems International d'Unites (SI)"
Metrication

6.4 Changes from previous issue. The margins of this standard are marked with asterisks to indicate where changes {additions, modifications, corrections, deletions) from the previous issue were made. This was done as a convenience only and the Government assumes *no* liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based *on* the entire content irrespective of the marginal notations and relationship to the last previous issue.

Custodians:
Army - MI
Navy - SH
Air Force - 01

Preparing activity:
Army - MI
(Project MISC-0130)

Review activity:
Army - AV
Air Force: 70, 71, 80, 82, 84, 99
DLA - GS

User activity:
Navy - YD
Air Force - 90

Appendix K

Draft Policy Statement: Metric Usage in the U.S. Shipbuilding Industry

APPENDIX K

DRAFT POLICY STATEMENT: METRIC USAGE IN THE U.S. SHIPBUILDING INDUSTRY

In recognition of the influences exerted by the U.S. Government and the world marketplace, it shall be the policy of the U.S. shipbuilding industry to maintain a proactive position regarding the adoption of the metric system in all of its shipbuilding practices. It shall be the industry's intent to use metric units of measure in its design, procurement, and construction practices as long as functionality, cost, and schedule are not materially and adversely affected. It shall also be the intent of the industry to work with shipowners, suppliers, and regulators to ensure that metric specification and standards are developed and invoked upon shipbuilding contracts at a pace and in a manner which assure the highest quality product economically available.

Additional copies of this report can be obtained from the National Shipbuilding Research Program Coordinator of the Bibliography of Publications and Microfiche Index. You can call or write to the address or phone number listed below.

NSRP Coordinator
The University of Michigan
Transportation Research Institute
Marine Systems Division
2901 Baxter Road
Ann Arbor, MI 48109-2150
Phone: (313) 763-2465
Fax: (313) 936-1081